Intergovernmental Oceanographic Commission

Workshop Report No. 91

Hydroblack '91 CTD Intercalibration Workshop

Woods Hole Oceanographic Institution
Woods Hole, USA
1-10 December 1991

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32 Suppl.	Papers submitted to the UNU/IOC/UNESCO Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime; Paris, 27 September-1 October 1982.	E
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36	IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, 28 May-2 June 1984.	E
36 Suppl.	Papers submitted to the IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, 28 May-2 June 1984.	E
37	IOC/UNESCO Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs; Colombo, 8-13 July 1985.	E
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region; Basrah, Iraq, 8-12 January 1984.	E
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific; Suva, Fiji, 24-29 September 1985.	E
40	IOC Workshop on the Technical Aspects of Tsunami Analysis, Prediction and Communications; Sidney, B.C., Canada, 29-31 July 1985.	E
40 Suppl.	IOC Workshop on the Technical Aspects of Tsunami Analysis, Prediction and Communications, *Submitted Papers;* Sidney, B.C., Canada, 29-31 July 1985.	E
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2); Dakar, Senegal, 28 October-1 November 1985.	E
43	IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean; Venice, Italy, 23-25 October 1985.	E
44	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E (out of stock) S
44 Suppl.	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities, *Submitted Papers;* Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E
45	IOCARIBE Workshop on Physical Oceanography and Climate; Cartagena, Colombia, 19-22 August 1986.	E
46	Reunión de Trabajo para Desarrollo del Programa "Ciencia Oceánica en Relación a los Recursos No Vivos en la Región del Atlántico Sud-occidental"; Porto Alegre, Brazil, 7-11 de abril de 1986.	S
47	IOC Symposium on Marine Science in the Western Pacific: The Indo-Pacific Convergence; Townsville, 1-6 December 1966.	E
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on 'Ocean Science in Relation to Non-Living Resources (OSNLR)'; Havana, Cuba, 4-7 December 1986.	E, S
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on 'El Niño'; Guayaquil, Ecuador, 27-31 October 1986.	E
50	CCALR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR); Paris, France, 2-6 June 1987.	E
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations; Lae, Papua-New Guinea, 1-8 October 1987.	E

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1-10 December 1991

by D.G. Aubrey, T. Oguz, E. Demirev, V. Ivanov, T. McSherry, V. Diaconu, and E. Nikolaenko

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Co-operative Marine Science Programme for the Black Sea (CoMSBlack)

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PREFACE

The Executive Council of the Intergovernmental Oceanographic Commission, at its Twenty-fifth Session (Paris, UNESCO, March 1992), recognized the important initiatives taken by scientists from Turkey, Ukraine, Russia, Bulgaria and Romania, as well as the USA and Germany that had resulted in the development of the scientific research programme called the "Co-operative Marine Science Programme for the Black Sea" (CoMSBlack) initiated in 1991.

In the report of its working group on monitoring and data base management, the "International Workshop on the Black Sea" held in Varna, Bulgaria, 30 September - 4 October 1991 (IOC Workshop Report No. 86) recommended that special attention should be given to intercalibration and improved quality control procedures to be applied at the source of the data as well as at all stages of the data flow in order to ensure that data are of the highest quality. Therefore, technical workshops to address these concerns as well as the provision of laboratory calibration instruments, measurement standards and other techniques to provide comparable and quality controlled data formed part of the first major field event in September 1991 under CoMSBlack, called HYDROBLACK'91.

With the publication of the report of the first intercalibration workshop for conductivity-temperature-depth (CTD) data acquired in 1991, to be followed by others to achieve complete quality controlled data sets not only for hydrographic but also chemical, biological and other data from the Black Sea basin, the Intergovernmental Oceanographic Commission promotes international efforts aimed at the establishment of the scientific data base in support for numerical modelling and calculations, strengthening systematic observations and related developments and for environmental assessment and planning towards achieving sustainable development in the unique Black Sea region.

1. ABSTRACT

An Intercalibration Workshop was held at the Woods Hole Oceanographic Institution (W.H.O.I.) from 1-10 December, 1991, for the CTD data acquired during HYDROBLACK '91. This intercalibration exercise was a prelude to an interdisciplinary HYDROBLACK '91 intercalibration to be held in Crimea, Ukraine, in February, 1992, incorporating the full suite of physical, biological, and chemical measurements acquired during the cruise.

HYDROBLACK '91 acquired for the first time a complete hydrographic, biological, and chemical data set for the entire Black Sea, to 2000 m water depth, with the participation of all Black Sea riparian countries as well as the U.S. Nearly 300 hydrographic stations were occupied to full water depth; biological and chemical measurements were made at 100 of these stations. This quasi-synoptic survey was accomplished using five ships during an interval of approximately three weeks.

Results show some disparities between CTD's from the different regions, but the intercalibrated results show a consistent and high resolution detail of the dynamic topography and other physical characteristics of the entire Black Sea basin. The intercalibrated data set is now available within each country and from W.H.O.I., and will form the basis for studies on ocean physics as well as interdisciplinary issues such as oxygen depletion within the basin and hydrogen sulfide distribution. This effort provides an intercalibrated, spatially-dense baseline against which all future and past measurements can be compared.

In spite of significant economic pressures arising from the changes in the eastern European countries, and the inadequate scientific exchange with the west during the past two decades, HYDROBLACK '91 is considered a success and a model for future international scientific and monitoring efforts throughout the Black Sea. Similar efforts are anticipated twice-yearly in the framework of the new Cooperative Marine Science Program for the Black Sea.

2. GOALS OF WORKSHOP

The goals of the Intercalibration Meeting include:

- Assess quality of HYDROBLACK 1991 data
- Intercalibrate the HYDROBLACK 1991 data sets using intercalibration stations and bottle sample results.
- Discuss scientific results of HYDROBLACK 1991: compare with known results of earlier cruises to Black Sea.
- Outline scientific paper(s) that will result from hydrographic results
- Complete Technical Report on Intercalibration Exercise
- Outline agenda for February, 1992, meeting in Sevastopol for HYDROBLACK 1991.
- Discuss goals of future Hydrographic work in Black Sea; prepare additional recommendations, if necessary, to VARNA meeting results.

The agenda for the intercalibration workshop is presented as Annex I.

3. CRUISE DESCRIPTION

Five ships participated in HYDROBLACK 1991 (Table 1). These ships all provided data from several different brands of CTD's, using to the extent possible similar procedures as outlined in the HYDROBLACK 1991 cruise plan (Erdemli, Turkey, July 1991: Annex II).

HYDROBLACK 91 accomplished nearly 300 hydrographic stations, using ships from three different Black Sea riparian countries. Two Ukrainian vessels (*Kolesnikov* and Parshin), two Turkish ships (*Bilim* and *Piri Reis*), and one Bulgarian vessel (*Akademik*) participated, occupying for the first time stations quasi-synoptically over the entire Black Sea within a period of three weeks. Station spacing was approximately 20 nm.

Table 1

**Ship and CTD Inventory
HydroBlack 1991**

Vessel	Country	CTD*	Dates	Number of Stations
R/V *Akademik*	Bulgaria	Sea Bird SBE-9	2 - 12 Sept 91	53
R/V *Bilim*	Turkey	Sea Bird SBE-9	5 - 23 Sept 91	104
R/V *Prof. Kolesnikov*	Ukraine	Istok V	9 - 29 Sept 91	94
R/V *Parshin*	Ukraine	Hydrozond	8 - 12 Sept 91	40
R/V *Piri Reis*	Turkey	Sea Bird SBE-9	7 - 17 Sept 91	16
			TOTAL	307

* Details on CTD's contained in Annex III and Table 2

Table 2

**CTD Data Specifications
HydroBlack 1991**

CTD MODEL	PRESSURE (DB)	CONDUCTIVITY (S/m)	TEMPERATURE (°C)	SAMPLE FREQUENCY (hz)
SEA BIRD SBE-9	+/- 2% (0-6000 m)	+/- 0.0004 S/m	+/- 0.003 °C	24
SEA BIRD SBE-19				2
ISTOK V	0.025% (0-60 MPa)	+/- 0.00025 S/m	0.025°C	4
HYDROZOND	0.04 - 0.6 MPa	+/- 0.0035 S/m	+/- 0.03°C	3

4. DATA ASSESSMENT

Data from all ships were loaded into a SUN Sparcstation II at the Woods Hole Oceanographic Institution. These data consisted of 1-decibar (db) bin-averaged data, as provided in Varna by the individual host countries following HYDROBLACK 1991. The data consisted of

in Varna by the individual host countries following HYDROBLACK 1991. The data consisted of ascii files of pressure (decibars), temperature (in situ, °C), salinity (psu), and density (sigma-t). In order to implement filtering and spike removal, data were converted to conductivity using the routine of Fofonoff and Millard (1983).

Instruments: The *Akademik*, *Bilim*, and *Piri Reis* used the same model of CTD: a Sea Bird SBE-9. The *Kolesnikov* used an Istok V CTD; the *Parshin* had available both a Sea Bird SBE-19 (for shallow stations) and a Hydrozond. Table 2 and Annex III provide details on the different CTD's used.

Data quality: Data from intercalibration stations were examined first to determine the quality of the data. An assessment of the data follows. The data examined were limited to deep stations (greater than 1000 db), since the spatial and temporal variability at these depths is less than elsewhere, and the dynamic range is more limited. The deep data were the best available to examine for drift and noise problems with the instruments.

4.1 ***Akademik*****:** These data are of high quality. Drift of the temperature sensor was small (Figure 1), with the drift being within the dynamic upper layer, and not within the deeper bottom mixed-layer. The drift likely represents dynamics within this deeper water (spatial variability). Differences in salinity reflect the differences in temperature (Figure 2): the largest differences are above the bottom mixed layer (bml), with less than 0.005 psu difference within the bml.

Occasionally, spikes occurred in salinity in the deeper waters. Spikes also occurred near the seasonal thermocline. The shallow spikes occurred because of ship heave due to heavy seas, combined with the slow lowering speed in the upper 100 meters (Figure 3). The lowering speed of 0.5 m/sec was modulated by surface waves, resulting in contaminated data within the strong gradients of the seasonal thermocline. In deeper waters, spikes (Figure 2) appeared that were linked with missing data (the modulo count on the Sea Bird was higher than 24). This resulted in both positive and negative spikes in conductivity and temperature, and hence in salinity. The cause of this spiking appears to be cable-related, either due to slip-ring problems or other cable problems.

4.2 ***Bilim*****:** These data appear to be of high quality. Temperature and salinity both appeared uniformly varying and noise-free. Long-term drift is small (less than 0.005 degrees C and 0.005 psu within the bml during the entire cruise: Figures 4 and 5). Convergence within the bml suggests the drift is due to spatial variability or dynamical changes. No spiking was observed in these data.

4.3 ***Kolesnikov*****:** These data were of high quality, but were noisier than the *Bilim* and *Akademik* data. The temperature signal taken at deep stations throughout the three weeks of sampling show several features (Figure 6):

4.3.1 Discontinuities in temperature, due to coarse discretization (reporting to 0.00x degrees C instead of 0.000x degrees C).

4.3.2 Staircases, where temperature "stuck" at a uniform value for more than 25 meters. For instance, one staircase occurred at 9.015°C throughout the cruise.

4.3.3 Space/time variability, with a spread of about 0.02 degrees C throughout the cruise. Since the temperatures shown are actual temperatures (not potential), the bml cannot be observed in temperature as a uniform layer, but these same 0.02°C differences persist in the bml itself at 1800 db levels and deeper. Since the bml is so uniform horizontally and vertically, this disparity represents a drift in the sensor.

The temperature drift was investigated through time, to see if the difference were linear as reported in a 1990 joint Soviet-Turkish Black Sea hydrographic experiment. Unfortunately, this drift was not linear (Figure 7).

The conductivity was uniform throughout the cruise, showing no drift. Salinity, however, reflects the temperature drift by showing large scatter in salinities (0.01 psu and greater) throughout the cruise Figure 8).

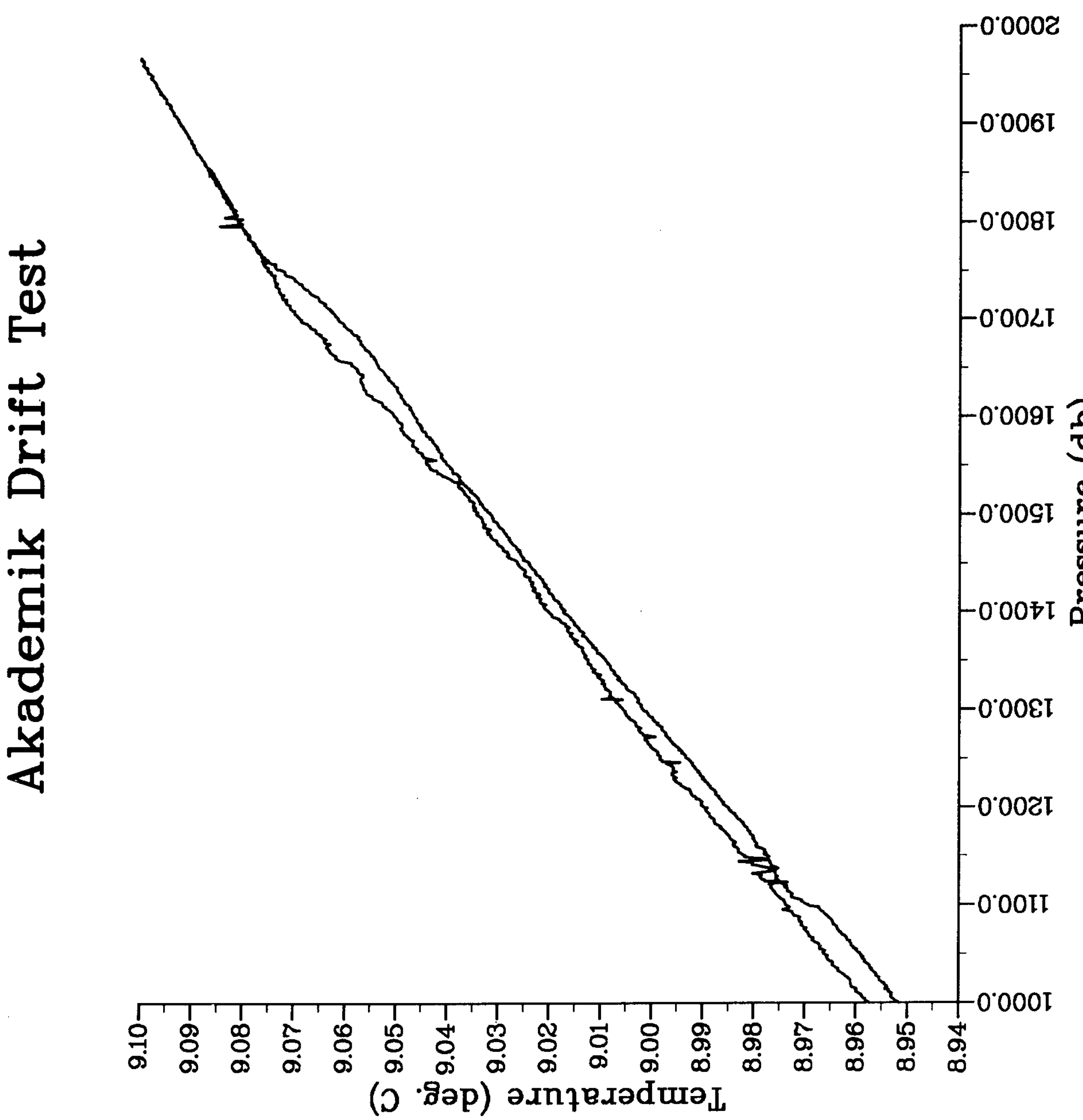


Figure 1: Temperature versus depth from the *Akademik*, during HYDROBLACK '91. Agreement of actual temperature within the bottom mixed layer shows no appreciable temperature drift through time. Spikes in the temperature signal appear to result from cable weakness, slip-ring noise, or perhaps a bad connector.

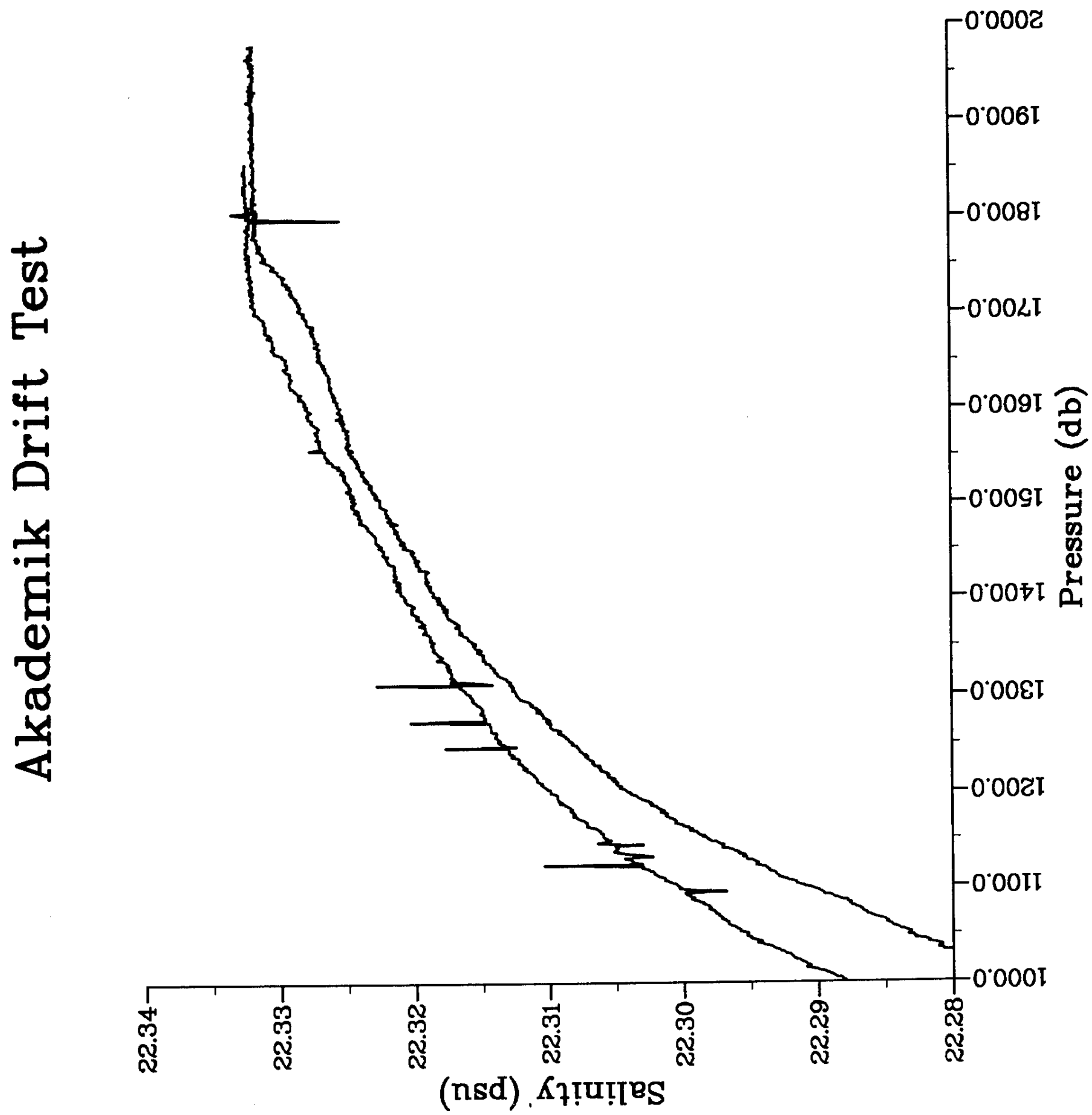


Figure 2: Salinity versus depth calculated for the *Akademik* casts of Fig. 1. The temperature spikes show up as marked salinity spikes. Salinity in the bottom mixed layer agrees well for the two casts.

fig 3

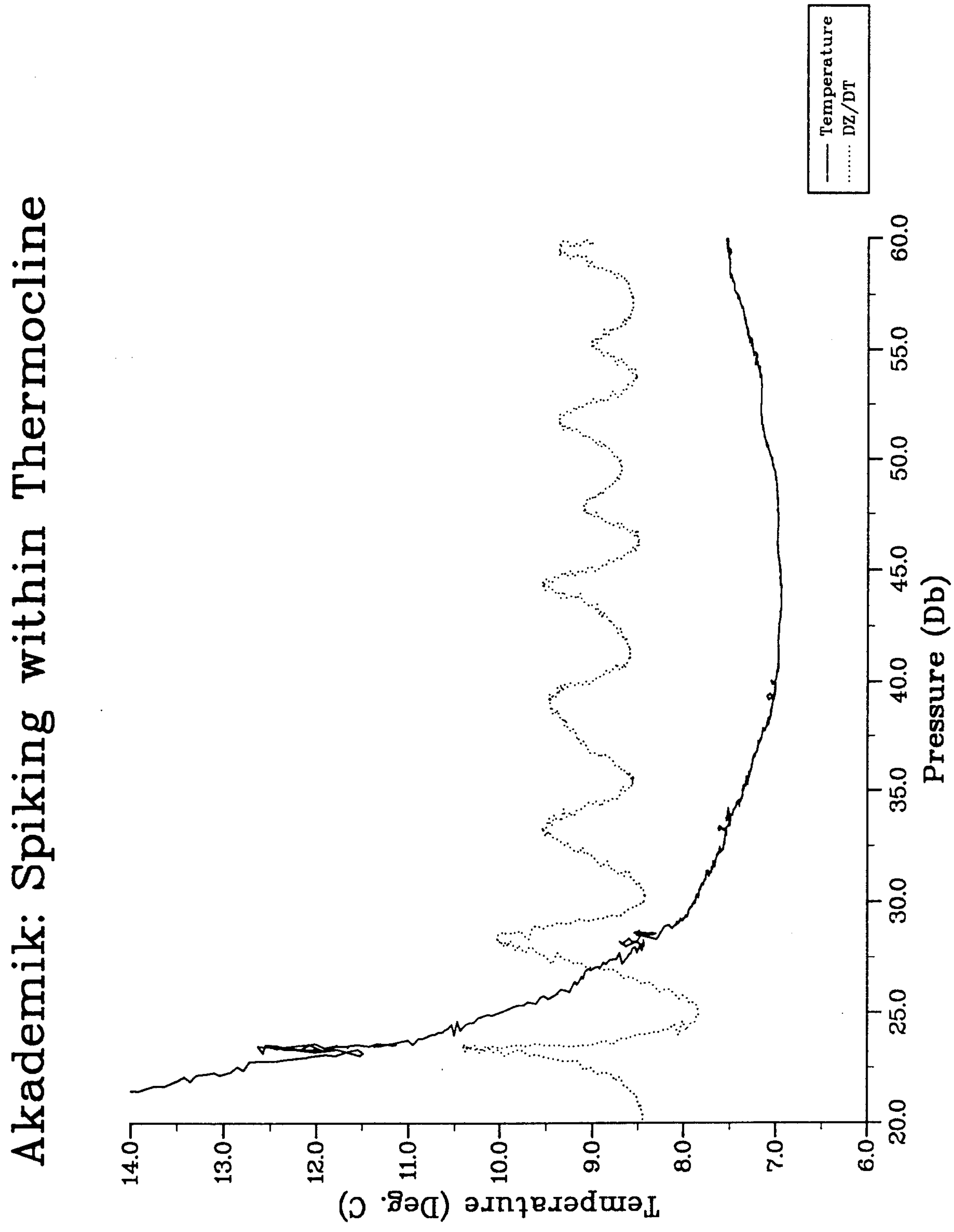


Figure 3: Temperature versus depth in the upper 60 db for the *Akademik* at one station. The solid line is the temperature from the CTD. The dashed line shows low-pass filtered vertical CTD velocity. Spikes in temperature within the thermocline occur when the vertical velocity changes rapidly, most likely due to ship motion caused by surface waves. The spike cannot be removed by simple filtering, and was exacerbated by too slow a lowering speed through the thermocline.

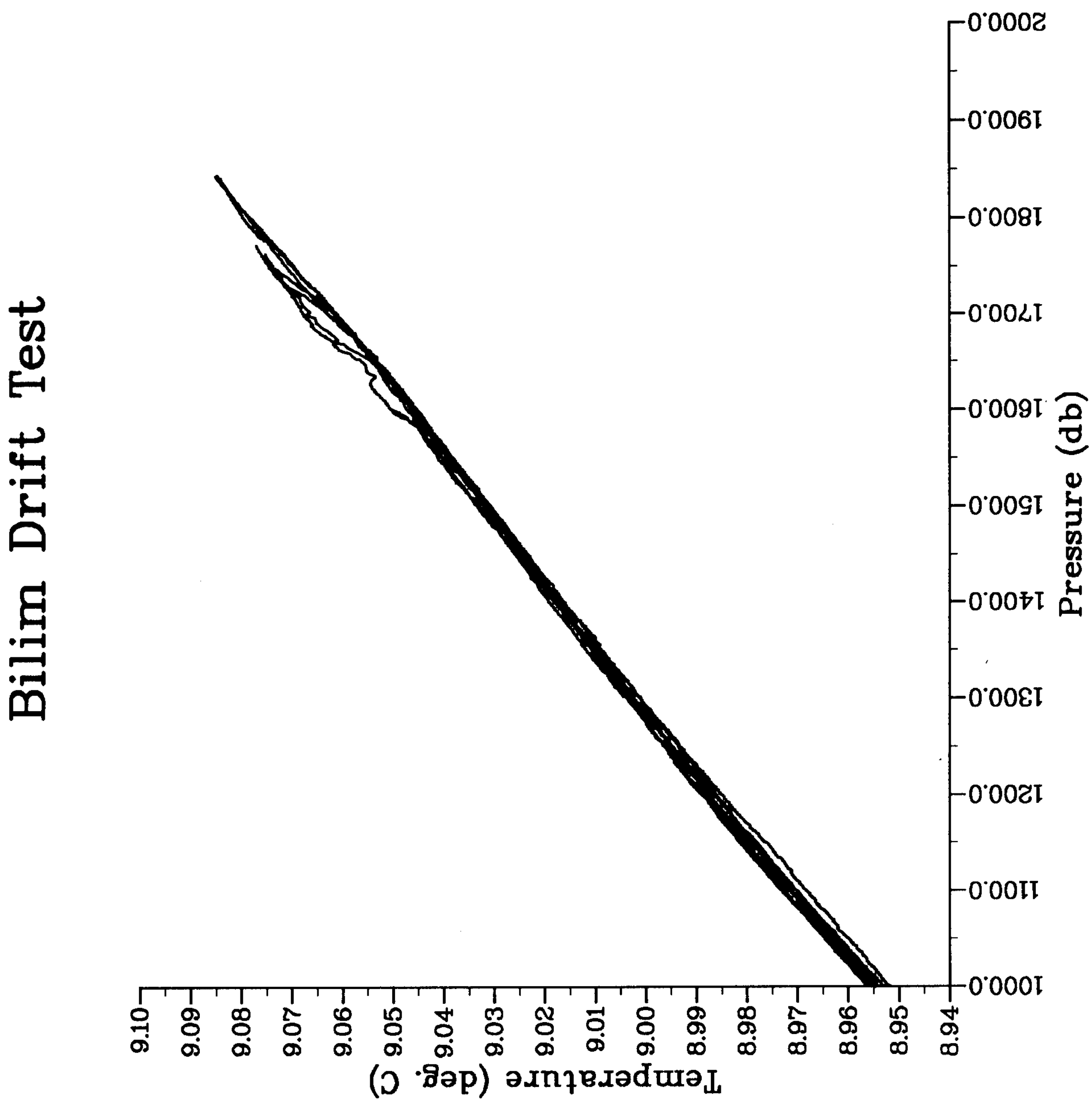


Figure 4: Temperature versus depth from the *Bilim*, during HYDROBLACK '91. Agreement of temperatures throughout most of the water column over the entire southern Black Sea during a period of two weeks indicates stability of the thermistor in the *Bilim* CTD. Wire length restrictions prevented the *Bilim* CTD from entering far into the bottom mixed layer.

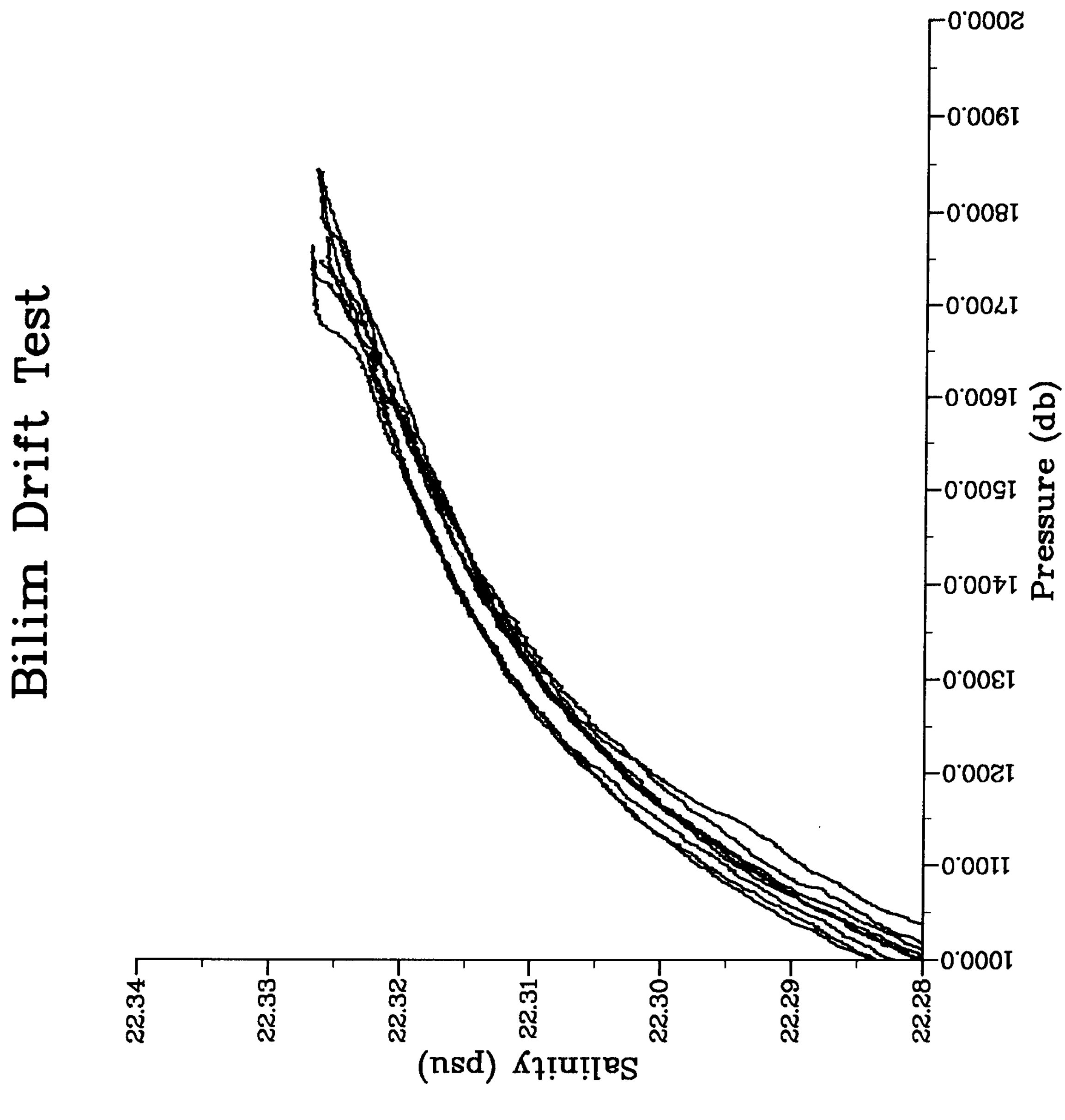


Figure 5: Salinity versus depth calculated for the *Bilim* casts of Fig. 4. As for temperature, the salinity data for the different casts are similar, especially near the bottom where they converge to a value of approximately 22.325 psu.

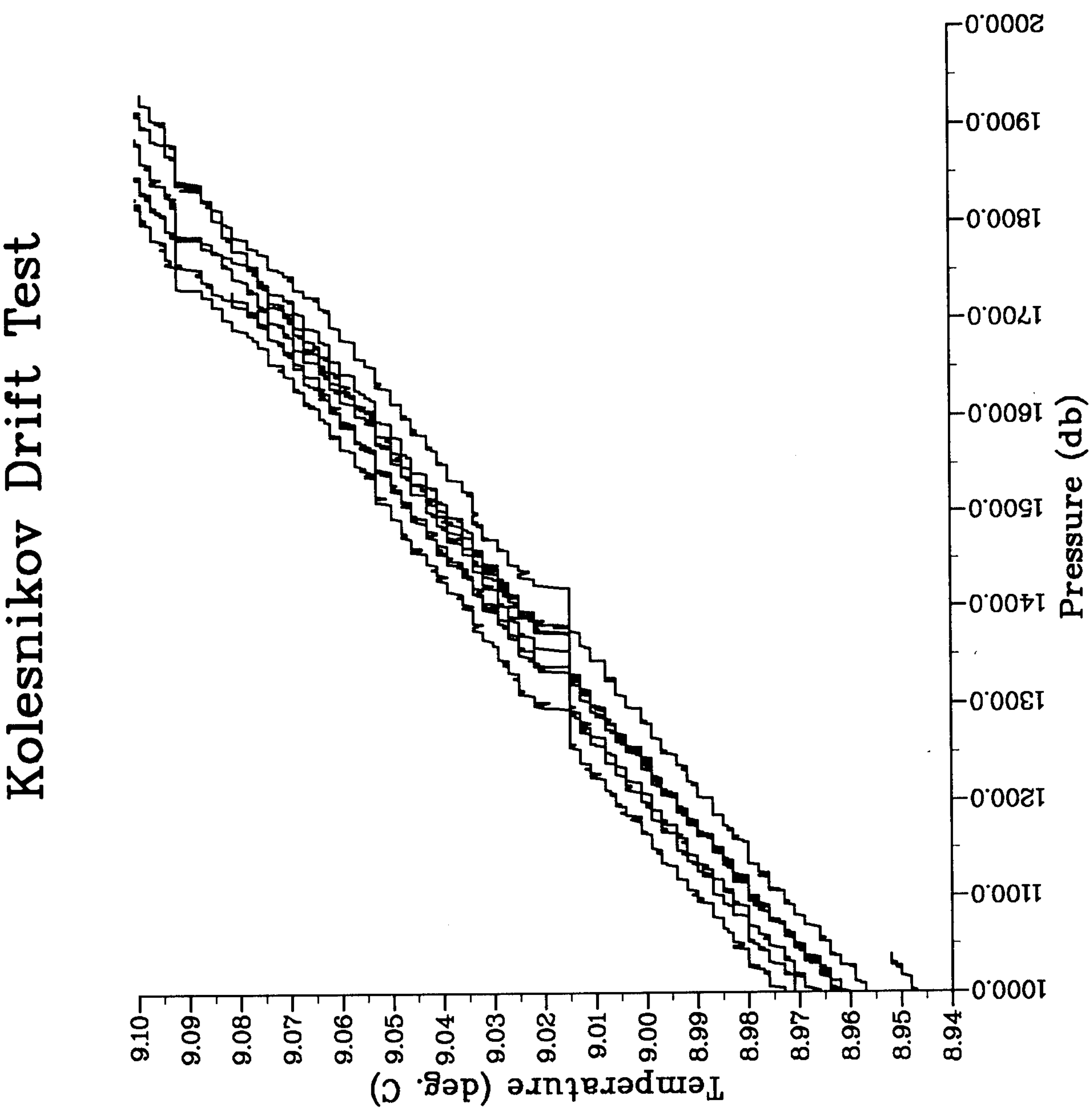


Figure 6: Temperature versus depth from the *Kolesnikov*, during HYDROBLACK '91. Temperature had several problems: the discretization interval is apparent in the graph by the jagged changes. Also, there is considerable drift in temperature (by about 0.02°C) during the course of the experiment. Finally, temperature sticks at certain levels (e.g., 9.015°C) for tens of meters water depth.

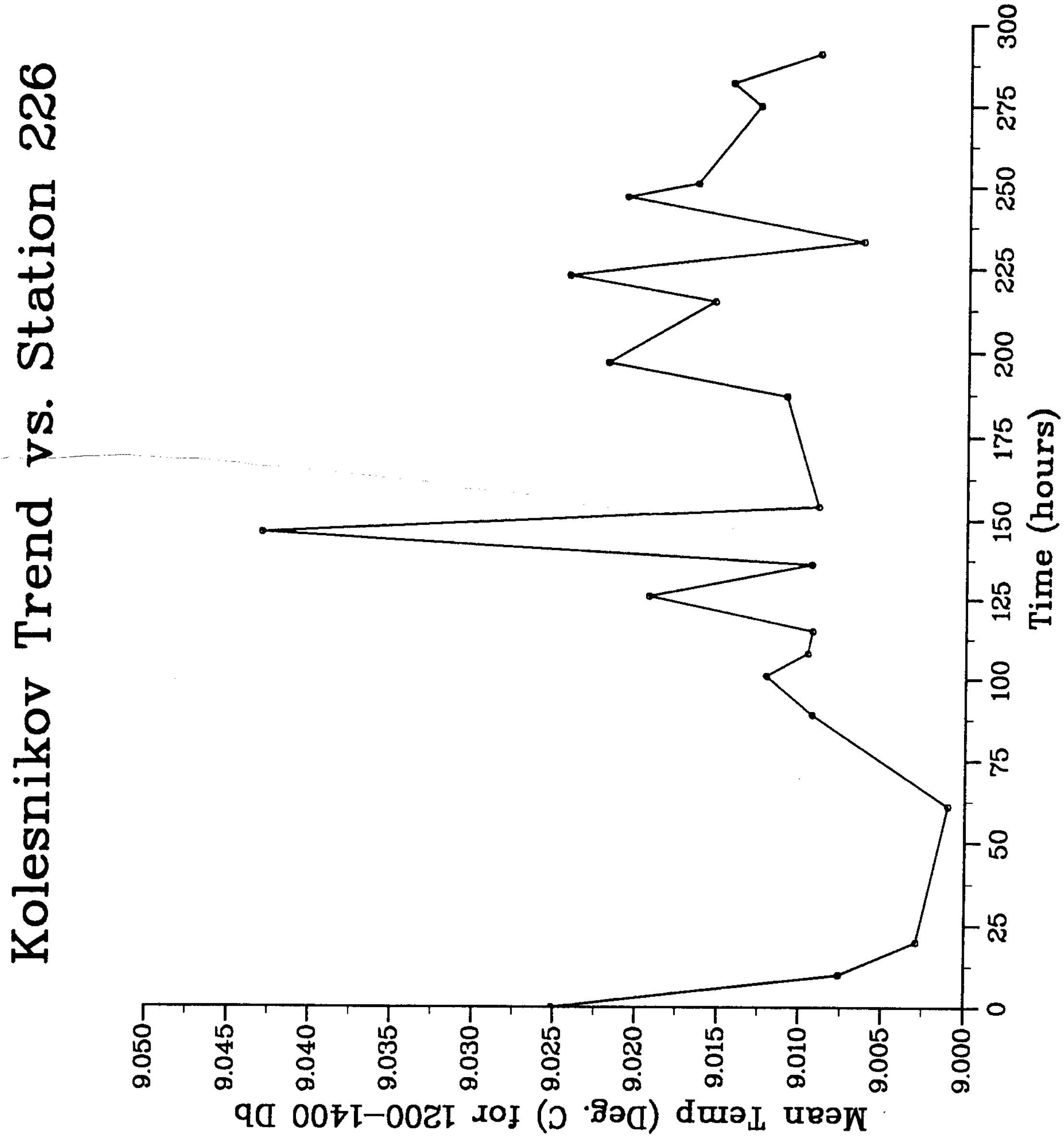


Figure 7: Mean temperature for the pressure levels of 1200-1400 db for the *Kolesnikov*. Horizontal axis is time from the first hydrographic cast of the *Kolesnikov*. The variability in temperature through time shows that a simple time-dependent temperature correction was not appropriate for the *Kolesnikov* data.

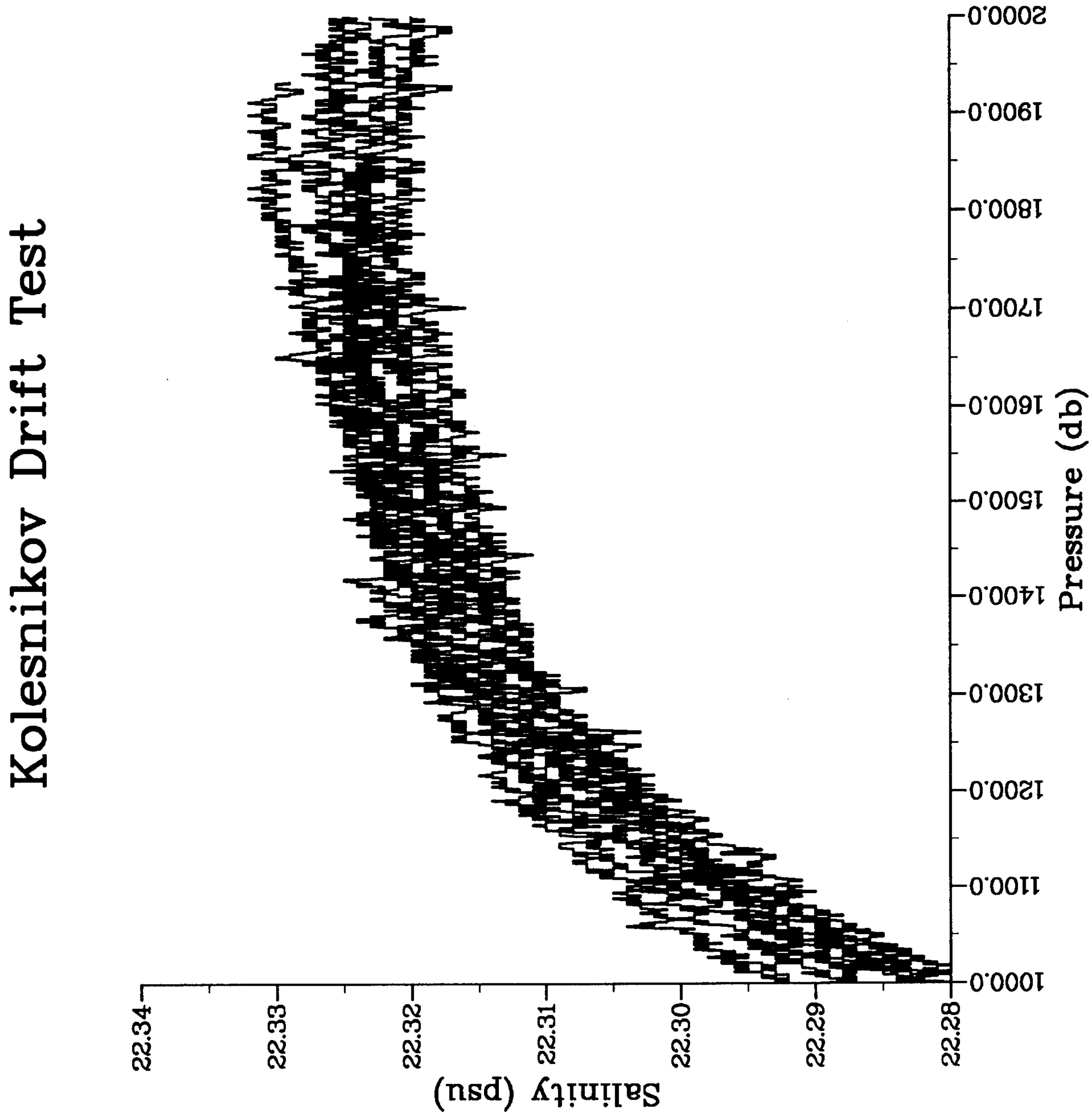


Figure 8: Salinity versus depth calculated for the *Kolesnikov* casts of Fig. 6. Salinity drift indicates several features: There is a notch-structure resulting from the coarse resolution of the thermistor. Salinity remains constant in several regions due to the sticking of the temperature at certain levels. Finally, there is strong curvature in the deeper waters, which result from a depth-dependent over-correction made to the conductivity measurement. This correction has the effect of artificially flattening salinity at greater depths.

4.4 ***Parshin*:** These data were taken with a coarse-resolution instrument (Hydrozond), and some data were taken also by a SeaBird SBE-19, before this latter instrument's pressure sensor failed halfway through the cruise (operator error). The SBE-19 data were of high quality, showing little spiking or other anomalies. The Hydrozond data, however, had greater difficulties. The Hydrozond's conductivity cell stopped working, so the sampling procedure consisted of lowering the thermistor and pressure sensors, examining the data, and then taking bottle samples analyzed on board for salinity. The result was a coarse resolution varying from a few meters to hundreds of meters in the deep stations. The accuracy of the instruments also is poor compared to the Sea Birds or Istok, so the deeper *Parshin* data were discarded. Only the shallow water data were used in this analysis.

4.5 ***Piri Reis:*** Only a few stations were run by the *Piri Reis*. These data appeared of similar quality as the *Bilim* and *Akademik* data. Temperature variability (Figure 9) was near zero in the bml, but showed a little structure above the bml. In salinity (Figure 10), the same variability shown by temperature exists, but the salinity in the bml is always uniform. The drift is small (less than 0.02 psu).

4.6 ***Knorr* 1988:** Although not part of this cruise, the *Knorr* 1988 data were examined for time and space variability. These data (reported by Murray et al. 1989 and several others) were high quality observations against which the present data could be compared. Two sets of profiles were examined in detail, consisting only of deep stations (to about 2000 db). The first set of profiles consists of stations throughout the Turkish part of the Black Sea (Figure 11), which would be indicative of spatial variability. The second set is taken from a single station, occupied repeatedly throughout the four-month duration of the *Knorr* cruise in the Black Sea.

Space variability in temperature is relatively small, with negligible variability within the bml (Figure 12). Variability between 1000 m and 2000 m was approximately 0.05 °C. Space variability in conductivity similarly was small, and negligible within the bml (Figure 13). Variability within the 1000-1800 db levels was approximately 0.002 S/m). Finally, spatial variability in salinity arising from the conductivity and temperature variability (Figure 14) is of the order of 0.005 psu in the bml. Variability is greater between 1000 and 2000 db levels.

Time variability in the *Knorr* data is similar as the spatial variability. The time variability in temperature (Figure 15) is of the order of 0.005 °C. Time variability in conductivity (Figure 16) is similar, with one higher measurement which might represent a different instrument. The variability in temperature and conductivity translate to a variability in salinity (Figure 17) of about 0.003 psu, with the exception of the one measurement having a high conductivity, which has a salinity within the bml higher by about 0.008 psu.

5. DATA INTERCALIBRATION

The intercalibration was accomplished on two bases: comparison of results from common stations, and the use of bottle samples to measure salinity. The two intercomparisons are described below here.

5.1 Intercalibration Stations: The HYDROBLACK 91 cruise plan (Annex II) laid out a series of intercalibration stations for the cruise (Figure 18), at which at least two ships would acquire measurements to the full water depth or to 2000 db, whichever was less. The two ships were to occupy these stations as synoptically as possible, but rough weather, poor communications at times, and instrument difficulties prevented some simultaneous measurements. On one occasion however, two ships (*Akademik* and *Parshin*) met for a simultaneous cast, even sharing a meal!

The goal of the intercalibration station was to provide in situ measurements of instrument performance, so the data could be compared and, if necessary, shifted for grouped analysis. The intercalibration was performed on temperature and conductivity, with comparisons made for salinity. Two intercalibration stations are presented for illustration. Station N30N45 (see Table 3 for a listing of station identification, analysis code, time and date of sampling, water depth, etc.)

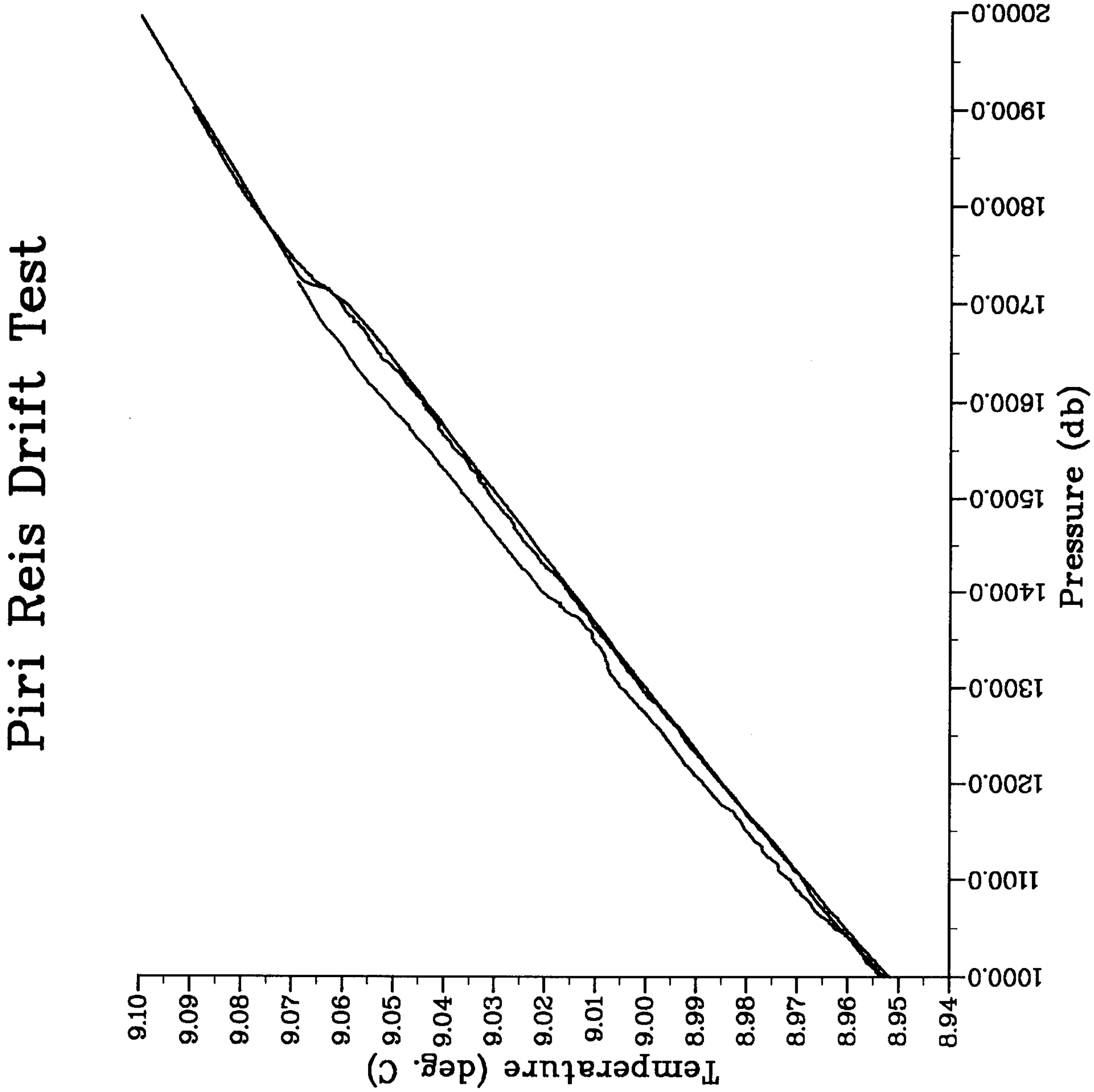


Figure 9: Temperature versus depth from the *Piri Reis*, during HYDROBLACK '91. Agreement of temperatures throughout most of the water column over the western Black Sea during a period of two weeks indicates stability of the thermistor in the *Piri Reis* CTD. In particular, actual temperature in the bottom mixed layer is nearly identical (to better than 0.001°C).

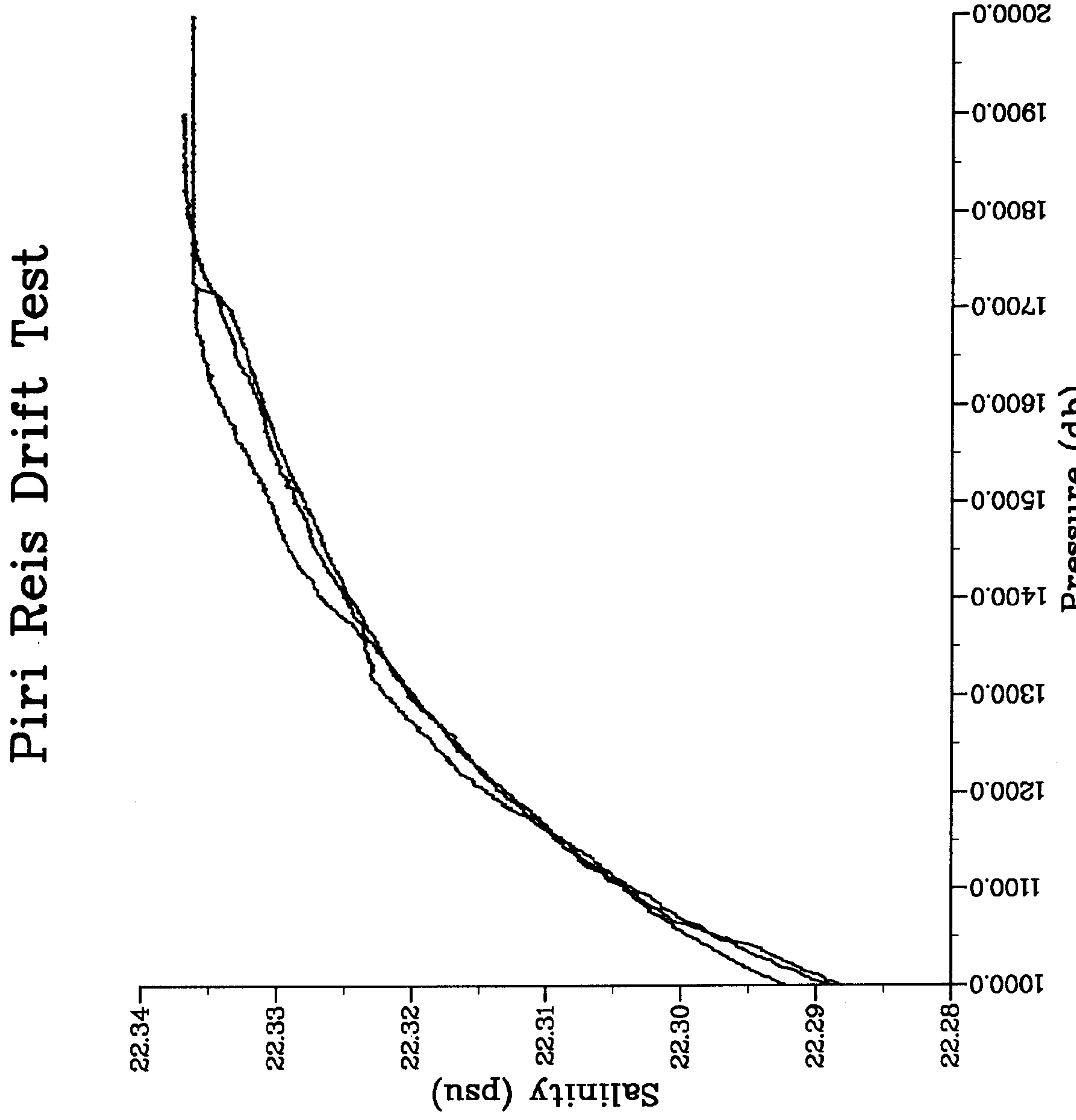


Figure 10: Salinity versus depth calculated for the *Piri Reis* casts of Fig. 9. As for temperature, the salinity data for the different casts are similar, especially near the bottom where they converge to a value of approximately 22.335 psu. This convergent value is higher by about 0.01 psu than the equivalent values for the *Bilim*.

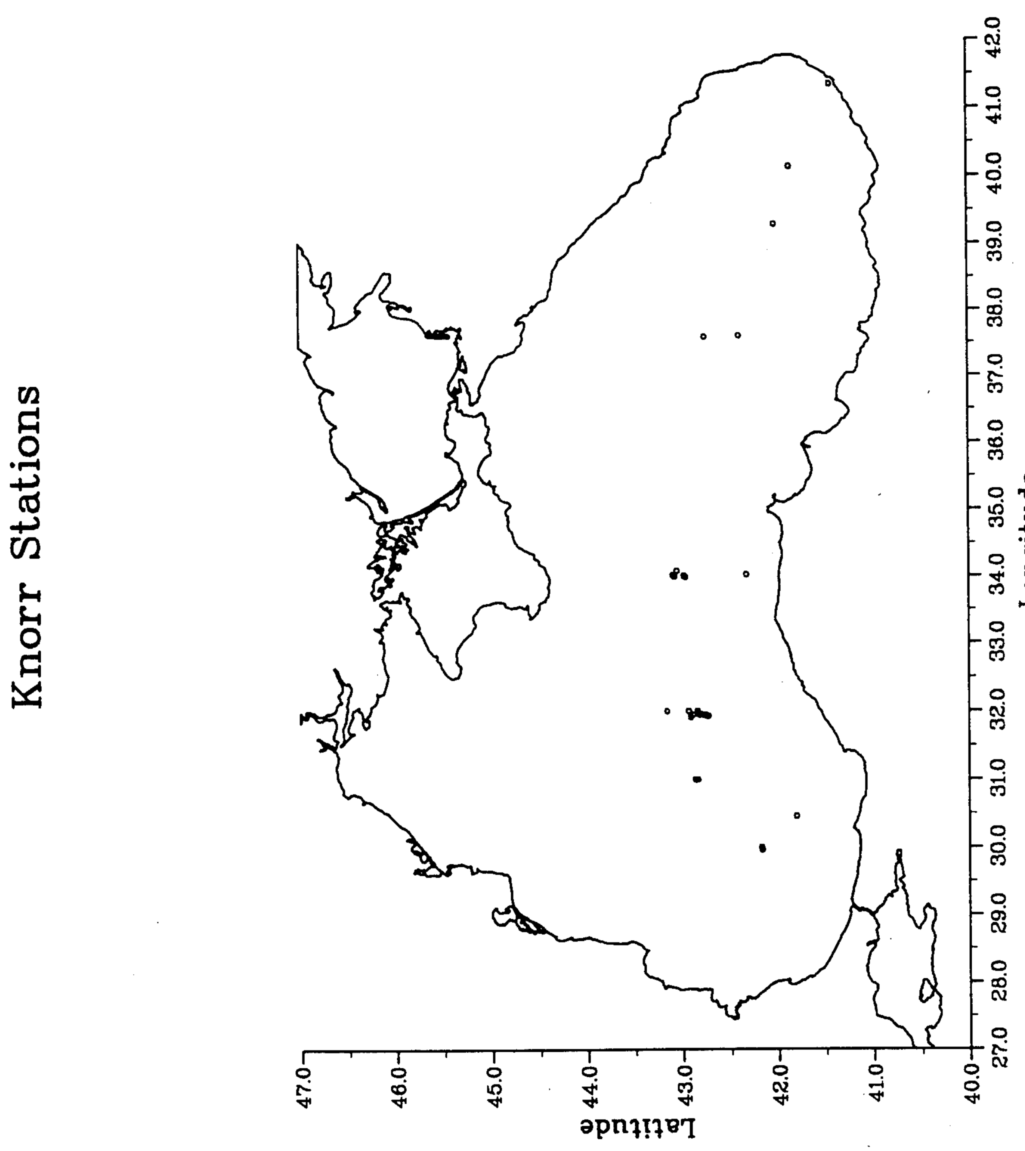


Figure 11: Positions of *Knorr* hydrographic stations from 1988.

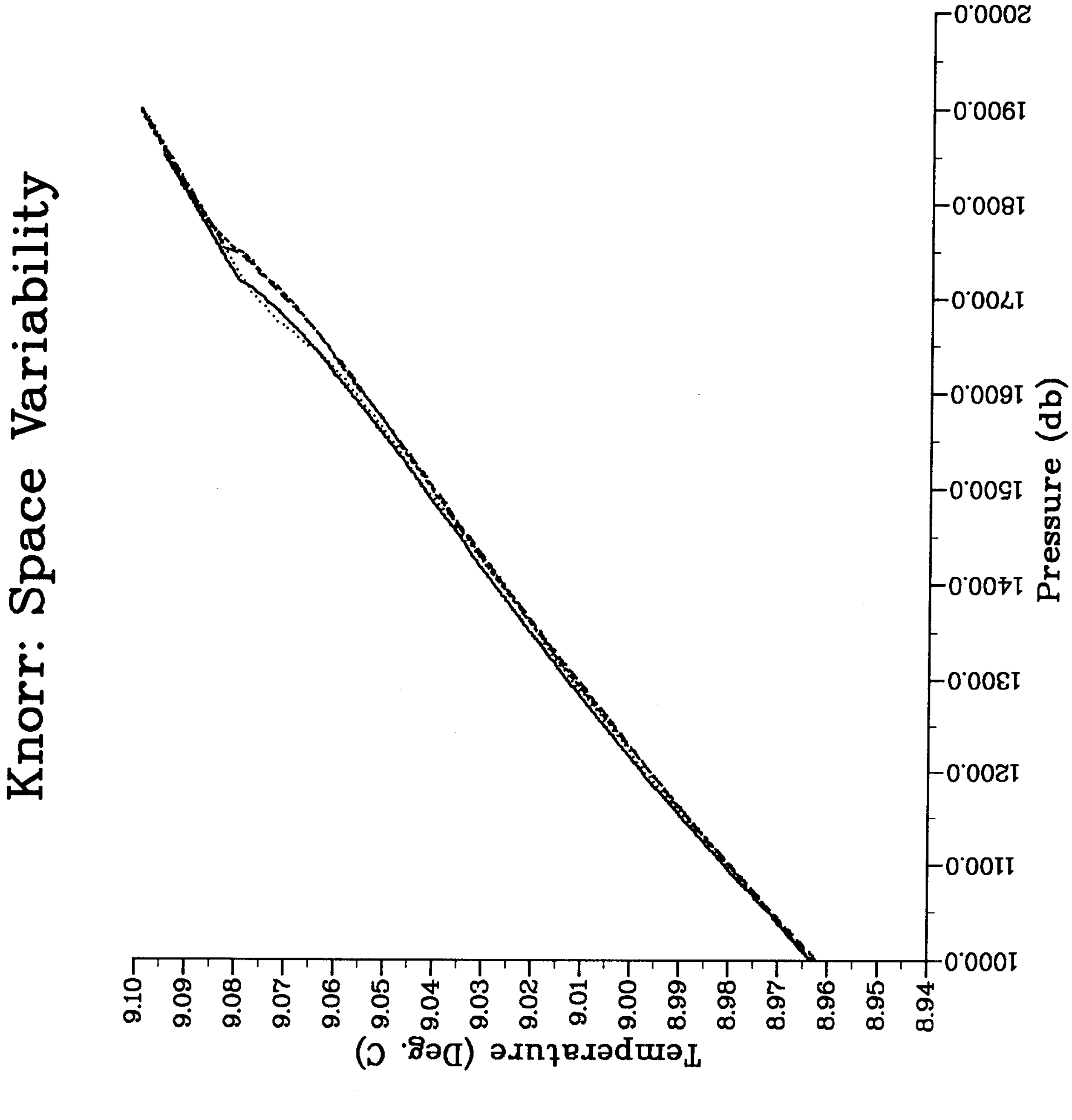


Figure 12: Temperature versus depth from the *Knorr*, for 1988, for some deep stations. Agreement of temperatures throughout most of the water column over the entire southern Black Sea during a period of several months indicates stability of the thermistor in the *Knorr* CTD. In particular, actual temperature in the bottom mixed layer is nearly identical (to less than 0.001°C).

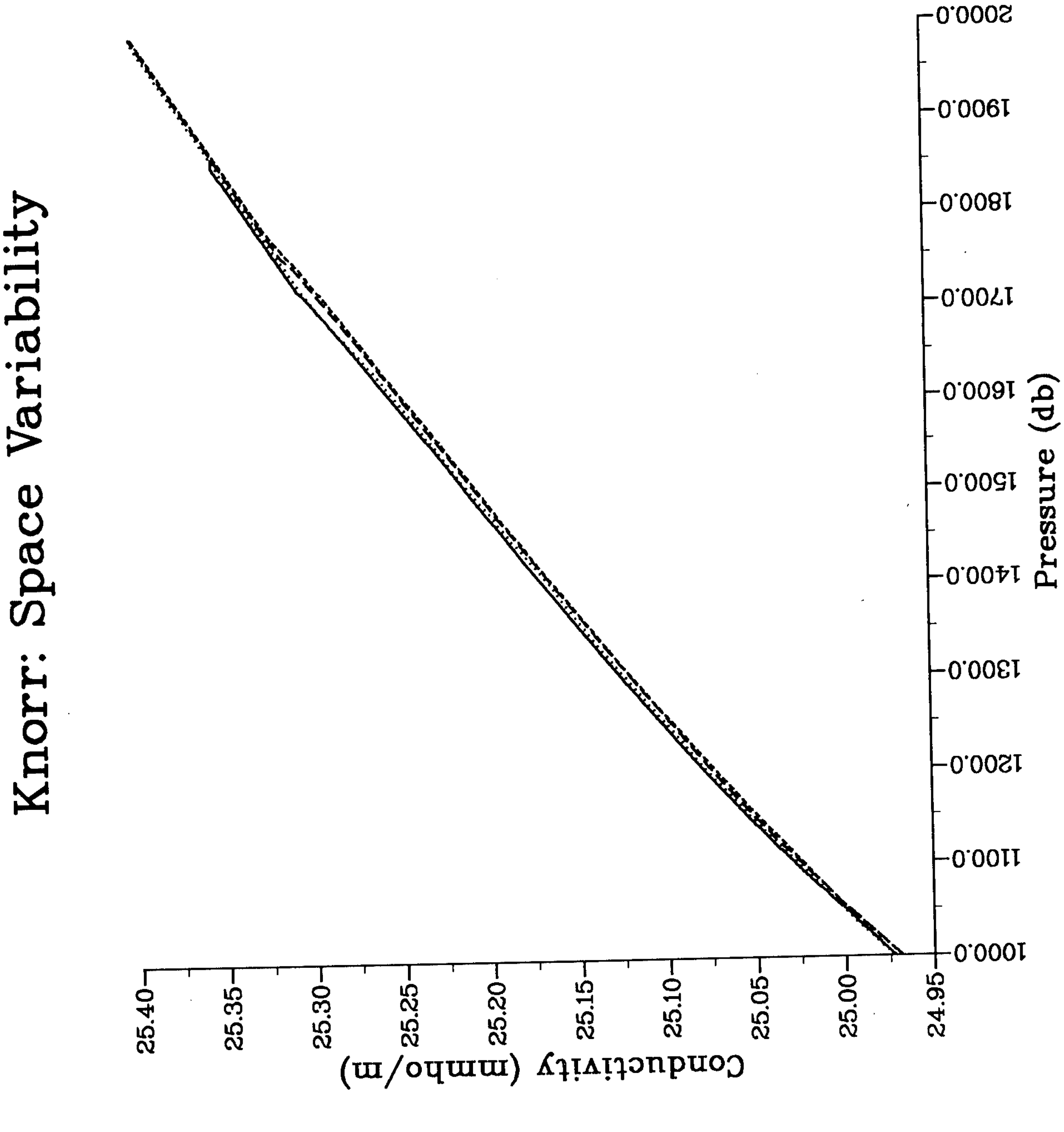


Figure 13: Conductivity versus depth from the *Knorr*, for 1988. Agreement of conductivity throughout most of the water column over the entire southern Black Sea during a period of several months indicates repeatability of the conductivity cell in the *Knorr* CTD, especially in the bottom mixed layer.

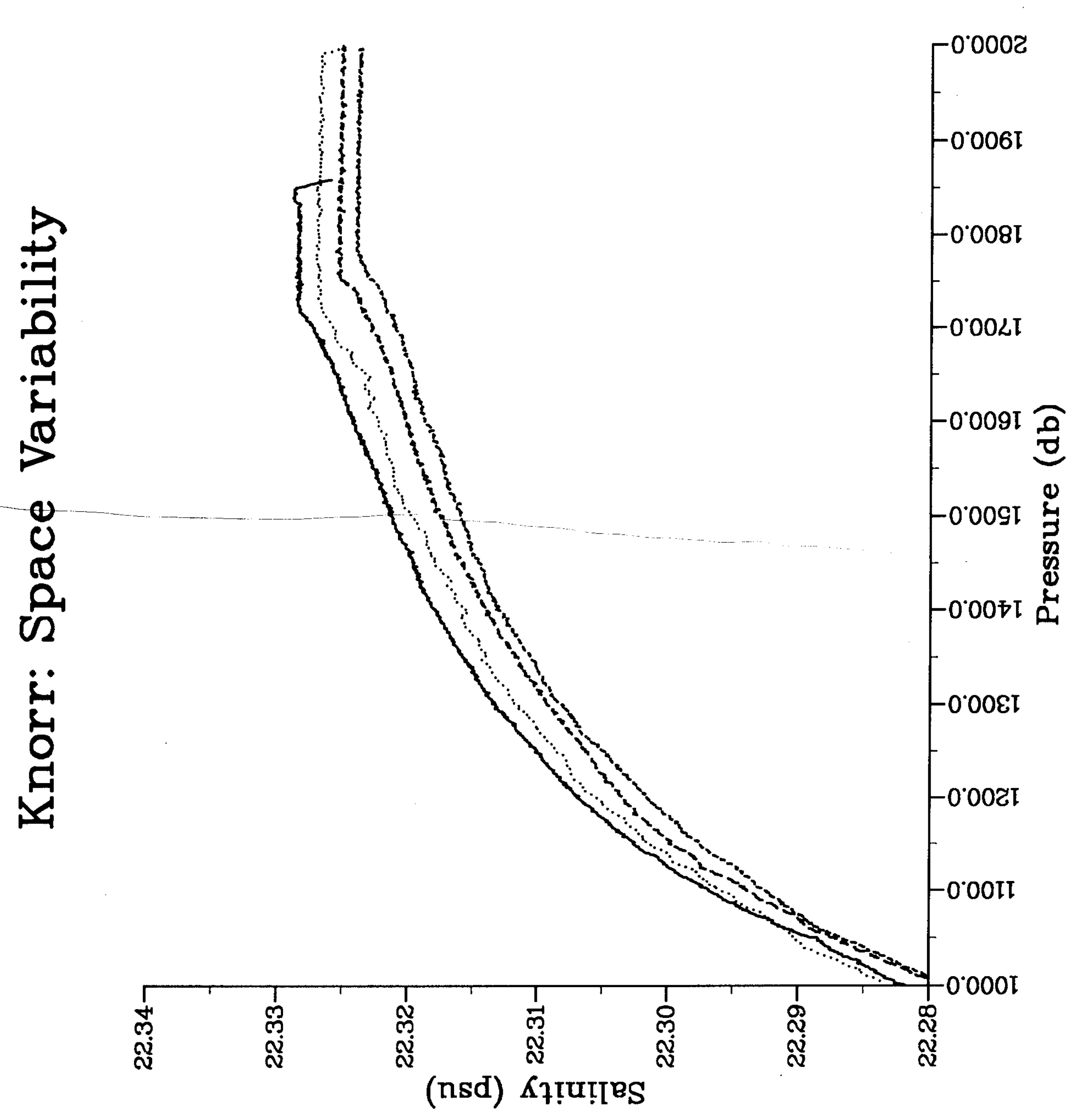


Figure 14: Salinity versus depth from the *Knorr*, for 1988, for some deep stations. Agreement of salinity throughout most of the water column over the entire southern Black Sea during a period of several months indicates good performance of the *Knorr* CTD, especially in the bottom mixed layer. Differences in the bottom mixed layer are about 0.005 psu.

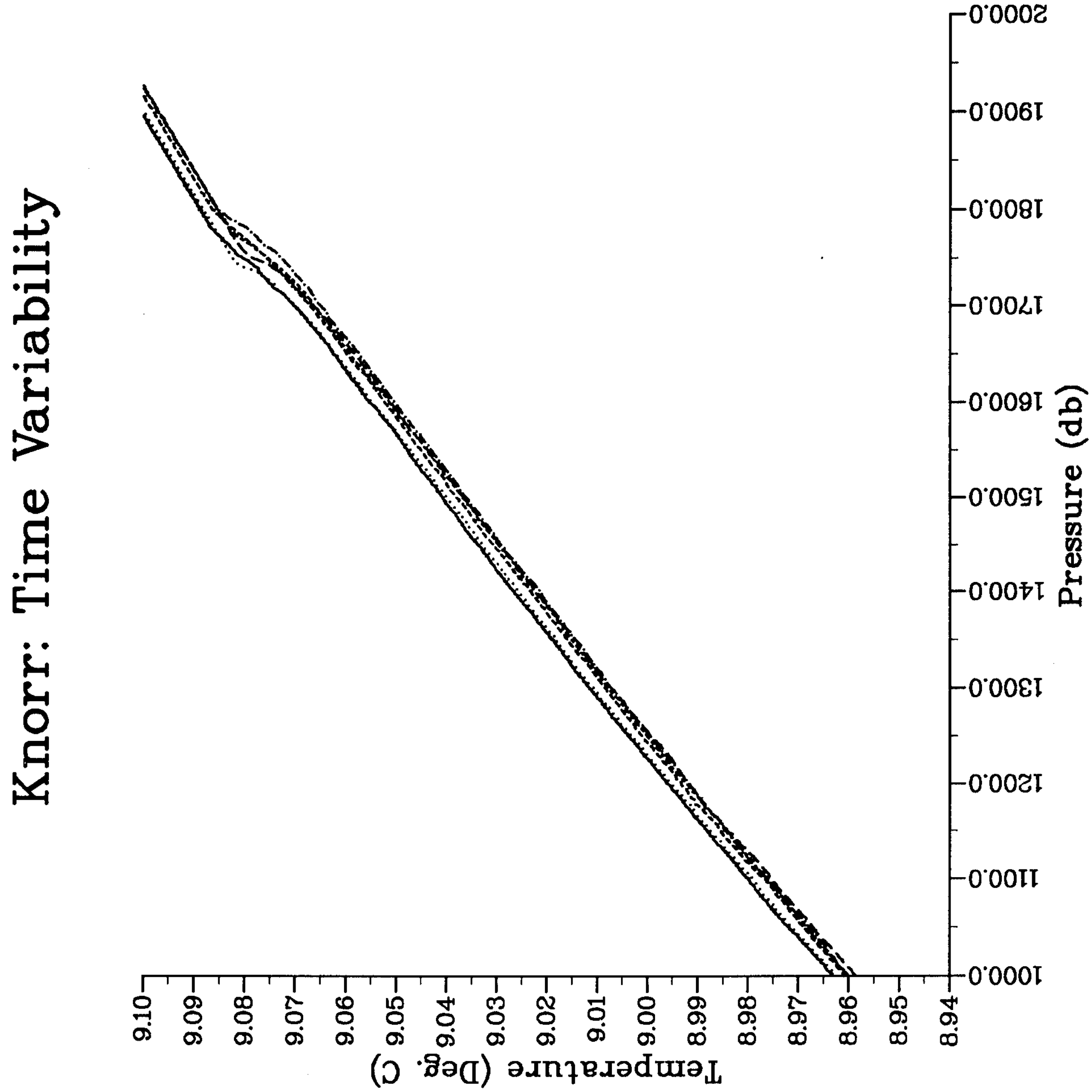


Figure 15: Temperature versus depth from the *Knorr*, for 1988, for a single deep station occupied repeatedly during a period of several months. Agreement of temperatures throughout most of the water column during a period of several months indicates stability of the thermistor in the *Knorr* CTD. In particular, actual temperature in the bottom mixed layer is nearly identical (to better than 0.005°C).

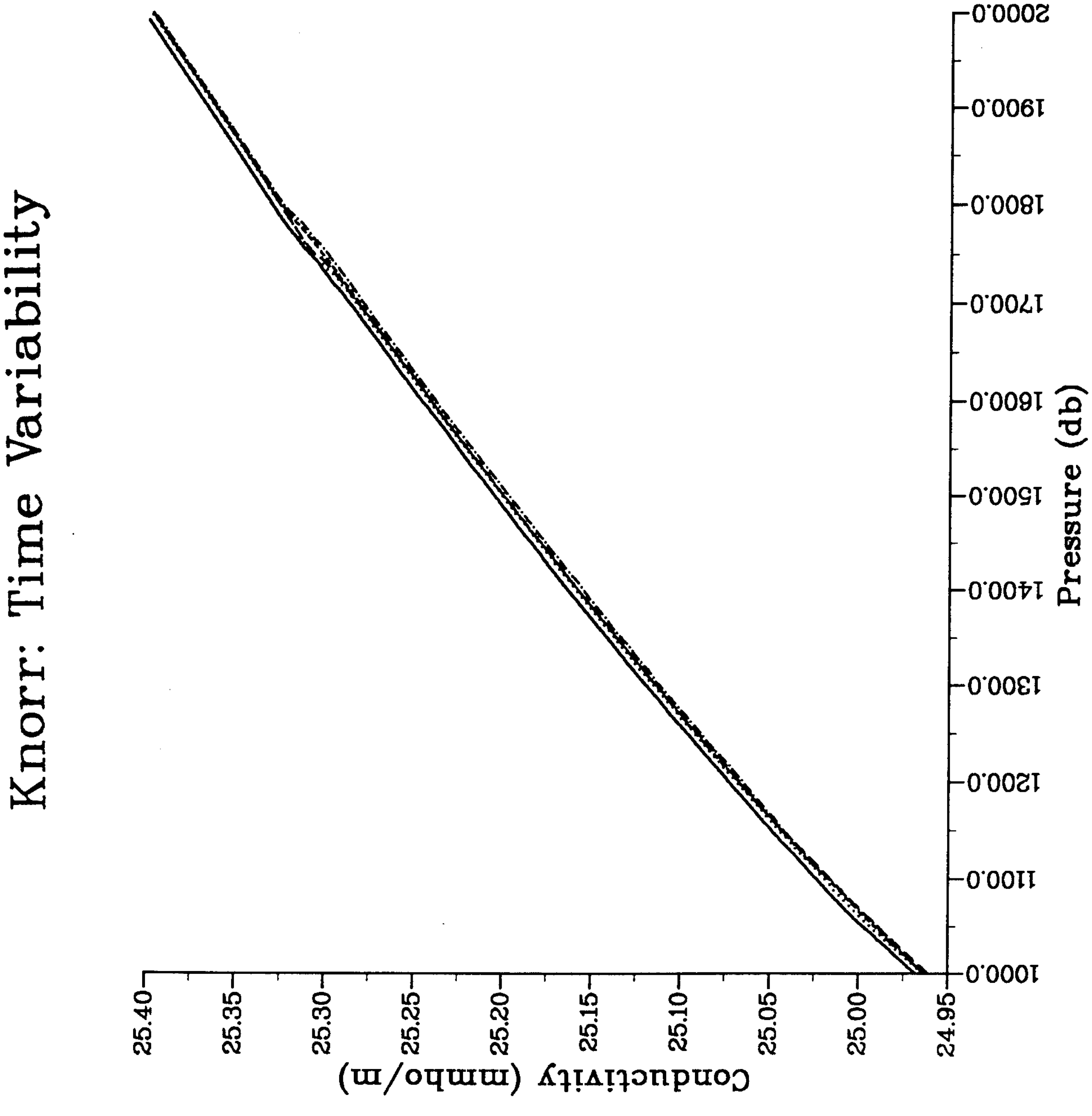


Figure 16: Conductivity versus depth from the *Knorr*, for 1988, for a single station during a period of several months. Agreement of conductivity throughout most of the water column during a period of several months indicates stability of the conductivity cell in the *Knorr* CTD, especially in the bottom mixed layer, where differences are on the order of 0.002 S/m.

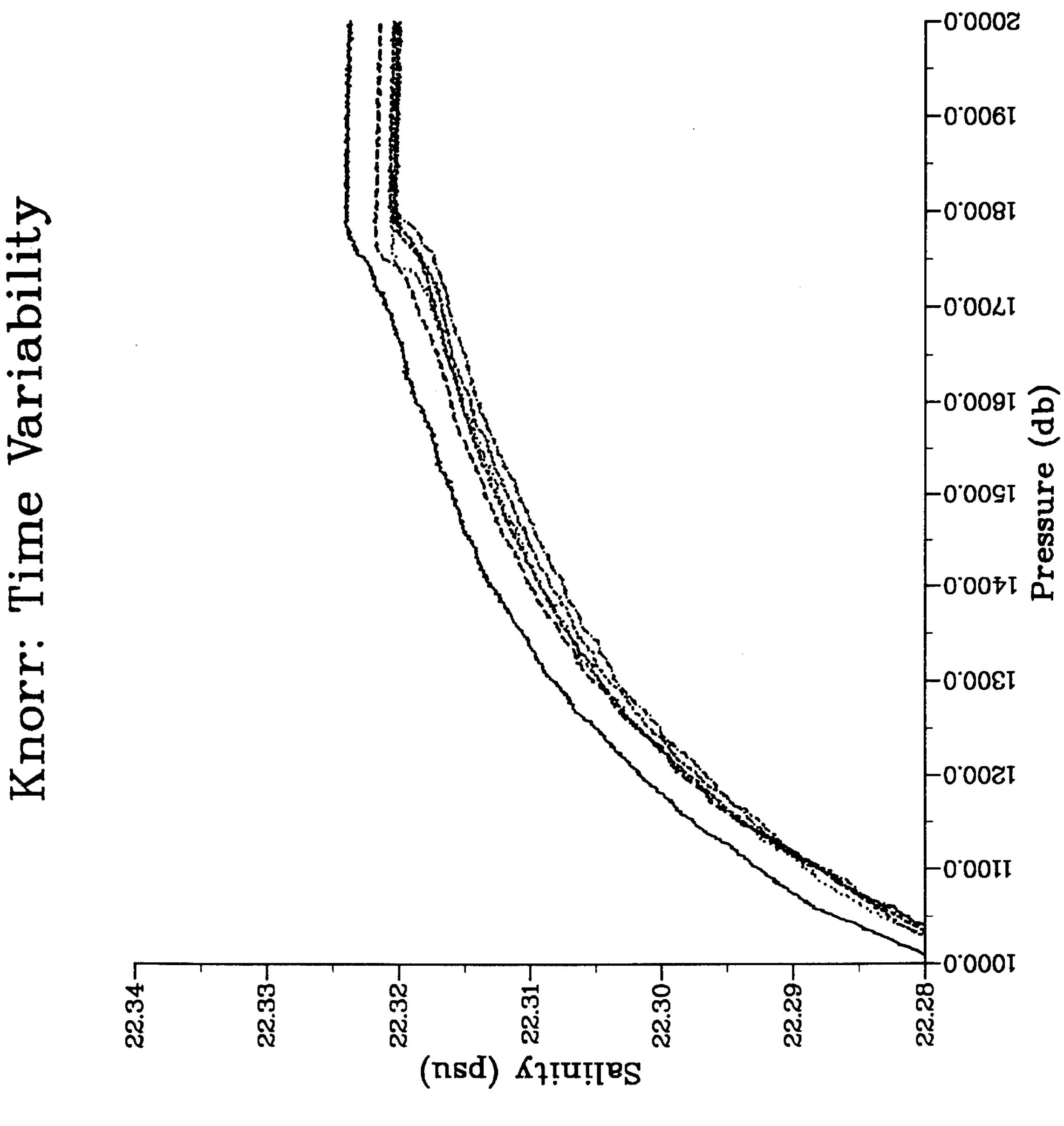


Figure 17: Salinity versus depth from the *Knorr*, for 1988, for a single deep station taking data during a period of several months. Agreement of salinity throughout most of the water column during a period of several months indicates good performance of the *Knorr* CTD, especially in the bottom mixed layer. Differences in the bottom mixed layer salinity are about 0.005 psu, the same level as the spatial variability described in Fig. 14.

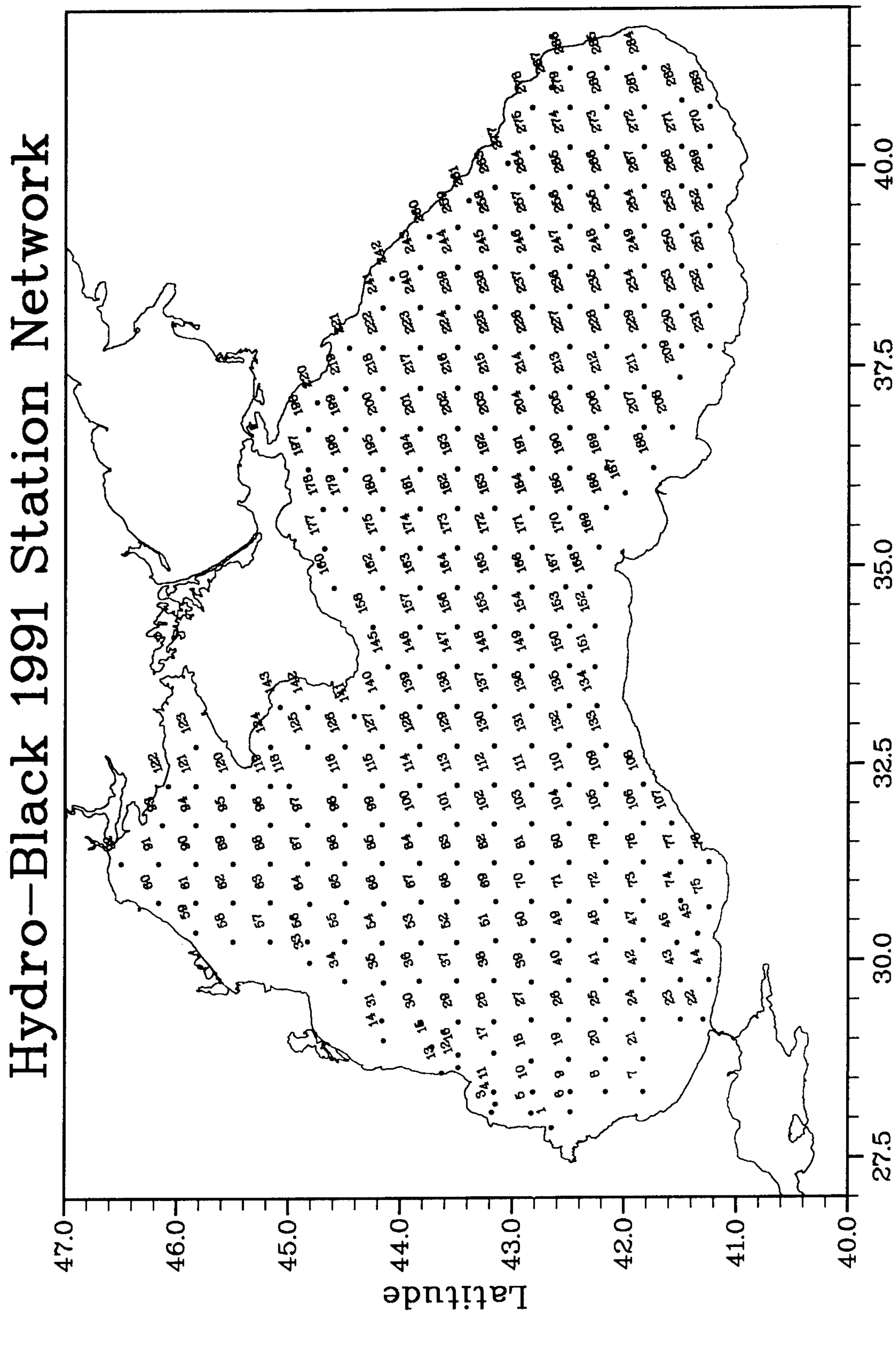


Figure 18: Station numbers and locations for HYDROBLACK '91 hydrographic casts.

TABLE 3

STATION CODES AND LOCATIONS

HYDROBLACK 1991 BLACK SEA CRUISE

R/V BILIM STATIONS

station	code	lat	long	depth (m)	date	time (GMT)
L50L45	42	41 50 00	29 45 00	2000	09-05-1991	14 10
M10M15	48	42 10 00	30 15 00	2000	09-05-1991	19 35
M50M45	70b	42 50 00	30 45 00	2100	09-06-1991	02 20
N10N15	82b	43 10 00	31 15 00	1800	09-06-1991	06 05
N30N45	101b	43 30 00	31 45 00	1925	09-06-1991	10 50
N10P45	130	43 10 00	32 45 00	2180	09-06-1991	16 20
N10Q15	137	43 10 00	33 15 00	2100	09-06-1991	21 45
M16Q44	151	42 16 00	33 44 00	0900	09-07-1991	17 50
M15Q15	134	42 15 00	33 15 00	1900	09-07-1991	21 25
M30Q15	135	42 30 00	33 15 00	2100	09-07-1991	23 55
M50Q15	136	42 50 00	33 15 00	2100	09-08-1991	03 30
N10Q45	148b	43 10 00	33 45 00	2100	09-08-1991	07 30
M50Q45	149	42 50 00	33 45 00	2100	09-08-1991	11 00
M30Q45	150	42 30 00	33 45 00	2000	09-08-1991	14 10
M30R15	153	42 30 00	34 15 00	2100	09-08-1991	17 30
M16R15	152	42 16 00	34 15 00	0450	09-08-1991	20 10
M19R45	168	42 19 00	34 45 00	1200	09-08-1991	23 00
M14S15	169	42 14 00	35 15 00	2000	09-09-1991	11 00
M30S15	170	42 30 00	35 15 00	2000	09-09-1991	14 20
M32R45	167	42 32 00	34 45 00	2000	09-09-1991	17 40
M50R45	166	42 50 00	34 45 00	2100	09-09-1991	21 30
M50R15	154	42 50 00	34 15 00	2100	09-10-1991	01 20
N10R15	155b	43 10 00	34 15 00	2100	09-10-1991	04 35
N10R45	165	43 10 00	34 45 00	2100	09-10-1991	09 30
N10S15	172	43 10 00	35 15 00	2100	09-10-1991	14 05
N10S45	183	43 10 00	35 45 00	2100	09-10-1991	17 35
N10T15	192	43 10 00	36 15 00	2100	09-10-1991	22 30
N10T45	203	43 10 00	36 45 00	2100	09-11-1991	01 55
M50T45	204	42 50 00	36 45 00	2100	09-11-1991	05 30
M50T15	191	42 50 00	36 15 00	2100	09-11-1991	10 05
M50S45	184	42 50 00	35 45 00	2100	09-11-1991	13 40
M50S15	171	42 50 00	35 15 00	2100	09-11-1991	16 50
M30S45	185	42 30 00	35 15 00	2100	09-11-1991	22 00
M10S45	186	42 10 00	35 45 00	1765	09-12-1991	01 30
M00S56	187	42 00 00	35 56 00	1420	09-12-1991	04 05
M10T15	189	42 10 00	36 15 00	1400	09-12-1991	06 45
M30T15	190	42 30 00	36 15 00	2080	09-12-1991	09 50
M30T45	205	42 30 00	36 45 00	2090	09-12-1991	14 10
M30V15	213	42 30 00	37 15 00	2100	09-12-1991	17 50
M50V15	214	42 50 00	37 15 00	2100	09-12-1991	21 15
M50V45	226b	42 50 00	37 45 00	2100	09-13-1991	00 45
M30W15	236	42 30 00	38 15 00	2100	09-13-1991	06 30
M30V45	227	42 30 00	37 45 00	2100	09-13-1991	09 45
M10V45	228	42 10 00	37 45 00	2100	09-13-1991	13 10
M10V15	212	42 10 00	37 45 00	2000	09-13-1991	16 30
M10T45	206	42 10 00	36 45 00	1800	09-13-1991	21 00
L50T45	207	41 50 00	36 45 00	0560	09-13-1991	23 45
L50V15	211	41 50 00	37 15 00	1930	09-14-1991	02 30

L50V45	229	41	50	00	37	45	00	1900	09-14-1991	06	05
L30V45	230	41	30	00	37	45	00	1850	09-14-1991	09	50
L30W15	233	41	30	00	38	15	00	1960	09-14-1991	13	45
L50W15	234	41	50	00	38	20	00	2000	09-14-1991	17	35
M10W15	235	42	10	00	38	15	00	2100	09-14-1991	20	35
M10W45	248	42	10	00	38	45	00	2100	09-14-1991	23	50
L50W45	249	41	50	00	38	45	00	2050	09-15-1991	03	35
L30W45	250	41	30	00	38	45	00	1950	09-15-1991	06	20
L30X15	253	41	30	00	39	15	00	2000	09-15-1991	10	00
L50X15	254	41	50	00	39	15	00	2020	09-15-1991	13	05
M10X15	255	42	10	00	39	15	00	2050	09-15-1991	16	45
M10X45	266b	42	10	00	39	45	00	2050	09-15-1991	19	50
L50X45	267	41	50	00	39	45	00	1960	09-16-1991	00	15
L30X45	268	41	30	00	39	45	00	1950	09-16-1991	03	10
L30Y15	271	41	30	00	40	15	00	1770	09-16-1991	07	50
L50Y15	272	41	50	00	40	15	00	1850	09-16-1991	11	30
L50Y45	281	41	50	00	40	15	00	1650	09-16-1991	15	50
L30Y50	282	41	30	00	40	50	00	1660	09-16-1991	18	35
L15Y45	283	41	15	00	40	45	00	1380	09-16-1991	22	15
L15Y15	270	41	15	00	40	15	00	1630	09-17-1991	01	25
L15X45	269	41	15	00	39	45	00	1780	09-17-1991	05	35
L15X15	252	41	15	00	39	15	00	1460	09-17-1991	08	40
L15W45	251	41	15	00	38	45	00	1660	09-17-1991	12	20
L15W15	232	41	15	00	38	15	00	1460	09-17-1991	15	40
L15V45	231	41	15	00	37	45	00	1470	09-17-1991	18	50
L31V22	209	41	31	00	37	22	00	1580	09-17-1991	21	05
L35T45	208	41	35	00	36	45	00	0500	09-18-1991	02	45
L45T15	188	41	45	00	36	15	00	0920	09-18-1991	05	40
M10P45	133	42	10	00	32	45	00	2100	09-19-1991	10	00
M30P45	132	42	30	00	32	45	00	2100	09-19-1991	13	00
M50P45	131	42	50	00	32	45	00	2100	09-19-1991	16	00
M50P15	111	42	50	00	32	15	00	2100	09-19-1991	19	30
N10P15	112	43	10	00	32	15	00	2100	09-19-1991	22	20
N10N45	102	43	10	00	31	45	00	2100	09-20-1991	01	40
M50N45	103	42	50	00	31	45	00	2100	09-20-1991	04	30
M30N45	104	42	30	00	31	45	00	2100	09-20-1991	08	20
M30P15	110	42	30	00	32	15	00	2100	09-20-1991	11	45
M10P15	109	42	10	00	32	15	00	2100	09-20-1991	14	40
M10N45	105	42	10	00	31	45	00	2100	09-20-1991	18	50
L50N45	106	41	50	00	31	45	00	1630	09-20-1991	21	40
L50N15	78	41	50	00	31	15	00	2030	09-21-1991	01	25
M10N15	79	42	10	00	31	15	00	2100	09-21-1991	05	10
M30N15	80	42	30	00	31	15	00	2100	09-21-1991	08	35
M30M45	71	42	30	00	30	45	00	2100	09-21-1991	12	30
M10M45	72	42	10	00	30	45	00	2100	09-21-1991	15	50
L50M45	73	41	50	00	30	45	00	1900	09-21-1991	19	35
L30N15	77	41	30	00	31	15	00	1450	09-21-1991	23	45
L30M45	74	41	30	00	30	45	00	1400	09-22-1991	03	15
L15M40	75	41	15	00	30	40	00	1100	09-22-1991	05	30
L21M20	45	41	21	00	30	20	00	0100	09-22-1991	08	10
L32M13	46	41	32	00	30	13	00	1000	09-22-1991	09	30
L50M15	47	41	50	00	30	15	00	1980	09-22-1991	12	10
M10L45	41	42	10	00	29	45	00	2150	09-22-1991	17	25
L50L45	42	41	50	00	29	45	00	2000	09-22-1991	20	55

L30L45	43	41	30	00	29	45	00	1500	09-23-1991	00	50
L25L30	44	41	25	00	29	30	00	0600	09-23-1991	03	00

R/V K. PIRI REIS STATIONS

station	code	lat			long			depth	date	time	
L18L15	22	41	18	00	29	15	00	0080	09-07-1991	10	10
L30L15	23	41	30	00	29	15	00	0365	09-07-1991	14	00
L50K20	7	41	50	00	28	20	00	0070	09-07-1991	17	00
M10K20	8r	42	10	00	28	20	00	0100	09-07-1991	21	00
M10K45	20	42	10	00	28	45	00	0600	09-07-1991	23	30
L50K45	21	41	50	00	28	45	00	0400	09-08-1991	02	30
L50L15	24	41	50	00	29	15	00	1748	09-12-1991	14	15
M10L15	25	42	10	00	29	15	00	1924	09-12-1991	19	15
M30L15	26r	42	30	00	29	15	00	1976	09-12-1991	23	55
M30L45	40r	42	30	00	29	45	00	2106	09-13-1991	05	15
M30M15	49	42	30	00	30	15	00	2109	09-13-1991	11	15
M50M15	50r	42	50	00	30	15	00	2097	09-13-1991	14	45
M50N15	81	42	50	00	31	15	00	2094	09-13-1991	23	35
L15N15	76	41	15	00	31	15	00	0088	09-15-1991	11	45
L35N45	107	41	35	00	31	45	00	2000	09-16-1991	09	20
L50P15	108	41	50	00	32	15	00	2000	09-17-1991	13	35

R/V KOLESNIKOV STATIONS

station	code	lat			long			depth	date	time	
M50V45	226k	42	50	00	37	45	00	2150	09-09-1991	15	30
M50W15	237	42	50	00	38	15	00	2135	09-09-1991	19	15
M50W45	246	42	50	00	38	45	00	2110	09-09-1991	22	15
M30W45	247	42	30	00	38	45	00	2100	09-10-1991	02	00
M30X15	256	42	30	00	39	15	00	2050	09-10-1991	05	40
M30X45	265	42	30	00	39	45	00	1950	09-10-1991	08	55
M10X45	266k	42	10	00	39	45	00	1970	09-10-1991	12	30
M10Y15	273	42	10	00	40	15	00	1870	09-10-1991	15	40
M10Y45	280	42	10	00	40	45	00	1565	09-10-1991	18	35
L50Z15	284	41	50	00	41	15	00	1180	09-10-1991	22	55
M10Z15	285	42	10	00	41	15	00	1185	09-11-1991	01	40
M30Z15	286	42	30	00	41	15	00	0700	09-11-1991	04	40
M40Z00	287	42	40	00	41	00	00	1275	09-11-1991	07	10
M30Y45	279	42	30	00	40	45	00	1600	09-11-1991	09	25
M30Y15	274	42	30	00	40	15	00	1590	09-11-1991	13	05
M50Y45	278	42	50	00	40	45	00	1040	09-11-1991	18	00
M50Y15	275	42	50	00	40	15	00	0995	09-11-1991	20	45
N03Y03	277	43	03	00	40	03	00	1400	09-11-1991	23	05
N10X45	263	43	10	00	39	45	00	1530	09-12-1991	01	20
M50X45	264	42	50	00	39	45	00	1880	09-12-1991	05	25
M50X15	257	42	50	00	39	15	00	2000	09-12-1991	09	10
N10X15	258	43	10	00	39	15	00	1900	09-12-1991	11	45
N24X35	261	43	24	00	39	35	00	1370	09-12-1991	15	25
N30X15	259	43	30	00	39	15	00	1840	09-12-1991	18	50
N45X08	260	43	45	00	39	08	00	1050	09-12-1991	21	00

N30W45	244	43	30	00	38	45	00	2120	09-13-1991	00	20
N50W45	243	43	50	00	38	45	00	1740	09-13-1991	03	30
P05W37	242	44	05	00	38	37	00	1225	09-13-1991	06	00
P10W15	241	44	10	00	38	15	00	1790	09-13-1991	09	10
N50W15	240	43	50	00	38	15	00	2130	09-13-1991	12	25
N30W15	239	43	30	00	38	15	00	2144	09-13-1991	16	10
N10W45	245	43	10	00	38	45	00	2120	09-13-1991	21	25
N10W15	238	43	10	00	38	15	00	2140	09-14-1991	00	10
N30V45	224	43	30	00	37	45	00	2150	09-14-1991	04	30
N10V45	225	43	10	00	37	45	00	2160	09-14-1991	07	35
N10V15	215	43	10	00	37	15	00	2170	09-14-1991	11	15
N30V15	216	43	30	00	37	15	00	2165	09-14-1991	15	00
N50V45	223	43	50	00	37	45	00	2140	09-14-1991	18	30
N50V15	217	43	50	00	37	15	00	2130	09-14-1991	22	00
N50T45	201	43	50	00	36	45	00	0214	09-15-1991	01	10
N30T45	202	43	30	00	36	45	00	2175	09-15-1991	04	35
N30T15	193	43	30	00	36	15	00	2000	09-15-1991	08	50
N50T15	194	43	50	00	36	15	00	2000	09-15-1991	12	30
P10T45	200	44	10	00	36	45	00	1965	09-15-1991	19	25
P10V15	218	44	10	00	37	15	00	2000	09-15-1991	23	40
P10V45	222	44	10	00	37	45	00	0920	09-16-1991	03	40
P28V45	221	44	28	00	37	45	00	1780	09-16-1991	06	50
P30V15	219	44	30	00	37	15	00	1150	09-16-1991	09	45
P45V05	220	44	45	00	37	05	00	0810	09-16-1991	12	50
P50T45	198	44	50	00	36	45	00	0062	09-16-1991	14	45
P30T45	199	44	30	00	36	45	00	0990	09-16-1991	18	05
P10T15	195	44	10	00	36	15	00	1700	09-16-1991	21	50
P30T15	196	44	30	00	36	15	00	0750	09-17-1991	01	15
P50T15	197	44	50	00	36	15	00	0080	09-17-1991	04	05
P42S45	178	44	42	00	35	45	00	0600	09-17-1991	06	55
P30S45	179	44	30	00	35	45	00	1300	09-17-1991	09	20
P10S45	180	44	10	00	35	45	00	1890	09-17-1991	12	45
N50S45	181	43	50	00	35	45	00	2100	09-17-1991	15	15
N30S45	182	43	30	00	35	45	00	2200	09-17-1991	19	00
N30S15	173	43	30	00	35	15	00	2200	09-17-1991	22	25
N50S15	174	43	50	00	35	15	00	2200	09-18-1991	01	30
P10S15	175	44	10	00	35	15	00	2100	09-18-1991	04	10
P41S15	177	44	41	00	35	15	00	0730	09-18-1991	09	05
P36R45	160	44	36	00	34	45	00	1360	09-18-1991	12	00
P10R45	162	44	10	00	34	45	00	2160	09-18-1991	16	00
P15R15	158	44	15	00	34	15	00	1270	09-18-1991	20	10
N50R15	157	43	50	00	34	15	00	2140	09-19-1991	00	05
N50R45	164	43	50	00	34	45	00	2205	09-19-1991	03	10
N30R45	163	43	30	00	34	45	00	2210	09-19-1991	06	20
N10R15	155k	43	10	00	34	15	00	2215	09-19-1991	10	35
N10Q45	148k	43	10	00	33	45	00	2220	09-19-1991	13	55
N30R15	156	43	30	00	34	15	00	2220	09-19-1991	18	00
N30Q45	147	43	30	00	33	45	00	2190	09-19-1991	21	30
N50Q45	146	43	50	00	33	45	00	2100	09-20-1991	00	30
N50Q15	139	43	50	00	33	15	00	2000	09-20-1991	04	00
P10Q15	140	44	10	00	33	15	00	1890	09-20-1991	07	00
P25Q08	141	44	25	00	33	08	00	0670	09-20-1991	10	00
P07Q45	145	44	07	00	33	45	00	0955	09-20-1991	17	40
N30Q15	138	43	30	00	33	15	00	2180	09-20-1991	21	25

N30P45	129	43 30 00	32 45 00	2130	09-21-1991	04 00
N50P45	128	43 50 00	32 45 00	1925	09-21-1991	07 40
N50P15	114	43 50 00	32 15 00	1800	09-21-1991	11 15
N30P15	113	43 30 00	32 15 00	2000	09-21-1991	14 30
N30N45	101k	43 30 00	31 45 00	1915	09-21-1991	18 00
N50N45	100k	43 50 00	31 45 00	1635	09-21-1991	20 40
N50N15	84k	43 50 00	31 15 00	1660	09-21-1991	23 45
N30N15	83k	43 30 00	31 15 00	1615	09-22-1991	03 10
P30P45	126k	44 30 00	32 45 00	1500	09-28-1991	21 30
P10P45	127	44 10 00	32 45 00	1750	09-29-1991	01 00
P10P15	115	44 10 00	32 15 00	1595	09-29-1991	03 40
P30P15	116k	44 30 00	32 15 00	1415	09-29-1991	07 00
P30N45	98k	44 30 00	31 45 00	1190	09-29-1991	10 00
P10N45	99k	44 10 00	31 45 00	1200	09-29-1991	13 15
P10N15	85k	44 10 00	31 15 00	0750	09-29-1991	16 40

R/V AKADEMIK STATIONS

station	code	lat	long	depth	date	time
N10K05	3	43 45 00	28 05 00	0020	09-03-1991	13 00
N10K20	11	43 10 00	28 20 00	0040	09-03-1991	16 26
N10K50	17	43 10 00	28 50 00	0325	09-03-1991	21 10
N10L15	28	43 10 00	29 15 00	1640	09-04-1991	02 12
N10L45	38	43 10 00	29 45 00	1600	09-04-1991	06 45
N10M15	51	43 10 00	30 15 00	1743	09-04-1991	10 50
N10M45	69	43 10 00	30 45 00	1945	09-04-1991	15 05
N10N15	82a	43 10 00	31 15 00	1804	09-04-1991	19 05
N30N45	101a	43 30 00	31 45 00	1927	09-05-1991	01 55
N30N15	83a	43 30 00	31 15 00	1600	09-05-1991	06 30
N30M45	68	43 30 00	30 45 00	1400	09-05-1991	11 30
N30M15	52	43 30 00	30 15 00	1300	09-05-1991	15 50
N30L45	37	43 30 00	29 45 00	0820	09-05-1991	20 50
N30L15	29	43 30 00	29 15 00	0091	09-06-1991	02 00
N30K50	16	43 30 00	28 50 00	0074	09-06-1991	06 10
N30K40	12	43 30 00	28 40 00	0065	09-06-1991	10 50
M50K20	10	42 50 00	28 20 00	0092	09-06-1991	19 00
M40J50	1	42 40 00	27 50 00	0022	09-06-1991	22 03
M30K05	6	42 30 00	28 05 00	0066	09-07-1991	01 15
M50K05	5	42 50 00	28 05 00	0037	09-07-1991	05 35
M10K20	8a	42 10 00	28 20 00	0105	09-07-1991	11 30
M30K20	9	42 30 00	28 20 00	0098	09-07-1991	15 45
M30K45	19	42 30 00	28 45 00	1390	09-07-1990	18 50
M50K45	18	42 50 00	28 45 00	1160	09-07-1990	23 45
M50L15	27	42 50 00	29 15 00	2036	09-08-1991	03 20
M30L15	26a	42 30 00	29 15 00	2020	09-08-1991	06 50
M30L45	40a	42 30 00	29 45 00	2160	09-08-1991	12 00
M50L45	39	42 50 00	29 45 00	2110	09-08-1991	15 10
M50M15	50a	42 50 00	30 15 00	2150	09-08-1991	20 35
M50M45	70a	42 50 00	30 45 00	2160	09-09-1991	00 15
N50N15	84a	43 50 00	31 15 00	1590	09-09-1991	09 35
P10N15	85a	44 10 00	31 15 00	0721	09-09-1991	16 15
P30N15	86a	44 30 00	31 15 00	0600	09-09-1991	22 10

P50N15	87a	44 50 00	31 15 00	0066	09-10-1991	02 45
P50M45	64a	44 50 00	30 45 00	0066	09-10-1991	05 30
P30M45	65	44 30 00	30 45 00	0097	09-10-1991	07 50
P10M45	66	44 10 00	30 45 00	0126	09-10-1991	11 30
N50M45	67	43 50 00	30 45 00	1020	09-10-1991	14 50
N50M15	53	43 50 00	30 15 00	0116	09-10-1991	18 45
P10M15	54	44 10 00	30 15 00	0094	09-10-1991	20 00
P30M15	55	44 30 00	30 15 00	0072	09-10-1991	22 45
P50M15	56a	44 50 00	30 15 00	0050	09-11-1991	03 15
P50M00	33	44 50 00	30 00 00	0044	09-11-1991	05 25
P30L45	34	44 30 00	29 45 00	0059	09-11-1991	07 50
P10L00	14	44 10 00	29 00 00	0042	09-11-1991	13 00
P10L15	31	44 10 00	29 15 00	0051	09-11-1991	15 35
P10L45	35	44 10 00	29 45 00	0063	09-11-1991	19 00
N50L45	36	43 50 00	29 45 00	0074	09-11-1991	21 50
N50L15	30	43 50 00	29 15 00	0064	09-12-1991	00 05
N40K55	15	43 40 00	28 55 00	0058	09-12-1991	03 35
N39K36	13	43 39 00	28 36 00	0012	09-12-1991	06 25
N10K12	4	43 10 00	28 12 00	0025	09-12-1991	13 30
N10K02	2	43 10 00	28 02 00	0015	09-12-1991	15 05

R/V PARSHIN STATIONS

station	code	lat	long	depth	date	time
R30N15	92	46 30 00	31 15 00	0008	09-08-1991	21 10
R10M45	60	46 10 00	30 45 00	0020	09-08-1991	00 10
Q50M22	59	45 50 00	30 22 00	0017	09-08-1991	03 20
Q30M15	58	45 30 00	30 15 00	0025	09-08-1991	05 39
Q10M15	57	45 10 00	30 15 00	0024	09-08-1991	07 50
P50M15	56p	44 50 00	30 15 00	0045	09-08-1991	10 15
P50M15	64p	44 50 00	30 15 00	0062	09-08-1991	12 45
Q10M45	63	45 10 00	30 45 00	0040	09-08-1991	15 20
Q30M45	62	45 30 00	30 45 00	0037	09-08-1991	17 40
Q50M45	61	45 50 00	30 45 00	0016	09-08-1991	20 16
R10N15	91	46 10 00	31 15 00	0024	09-08-1991	23 10
Q50N15	90	45 50 00	31 15 00	0021	09-09-1991	01 10
Q30N15	89	45 30 00	31 15 00	0041	09-09-1991	03 20
Q10N15	88	45 10 00	31 15 00	0052	09-09-1991	05 40
P50N15	87p	44 50 00	31 14 00	0063	09-09-1991	07 45
P30N15	86p	44 30 00	31 15 00	0620	09-09-1991	10 10
P10N15	85p	44 10 00	31 15 00	0760	09-09-1991	18 00
N50N15	84p	43 50 00	31 15 00	1470	09-09-1991	22 10
N30N15	83p	43 30 00	31 15 00	1600	09-10-1991	02 40
N30N45	101p	43 30 00	31 45 00	1926	09-10-1991	08 35
N52N40	100p	43 52 00	31 40 00	1500	09-10-1991	15 00
P12N44	99p	44 12 00	31 44 00	1220	09-10-1991	22 00
P30N45	98p	44 30 00	31 45 00	1090	09-11-1991	02 55
P49N44	97	44 49 00	31 44 00	0059	09-11-1991	06 45
Q10N45	96	45 10 00	31 45 00	0051	09-11-1991	09 00
Q30N45	95	45 30 00	31 45 00	0044	09-11-1991	11 15
Q50N46	94	45 50 00	31 46 00	0027	09-11-1001	13 30
R08N45	93	46 08 00	31 45 00	0009	09-11-1991	15 30

R05P16	122	46	05	00	32	16	00	0008	09-11-1991	17	45
Q50P45	123	45	50	00	32	45	00	0022	09-11-1991	20	15
Q49P15	121	45	49	00	32	15	00	0026	09-11-1991	22	15
Q30P15	120	45	30	00	32	15	00	0035	09-12-1991	00	19
Q10P15	119	45	10	00	32	15	00	0048	09-12-1991	02	30
Q00P16	118	44	00	00	32	16	00	0075	09-12-1991	03	50
P30P15	116p	44	30	00	32	15	00	1380	09-12-1991	06	45
P31P45	126p	44	31	00	32	45	00	0780	09-12-1991	11	10
P50P45	125	44	50	00	32	45	00	0130	09-12-1991	13	40
P49Q16	142	44	49	00	33	16	00	0092	09-12-1991	16	05
Q05Q15	143	45	05	00	33	15	00	0022	09-12-1991	17	55
Q10P45	124	45	10	00	32	45	00	0070	09-12-1991	20	15

was occupied by the *Akademik*, *Bilim*, and *Kolesnikov* (Figure 19), and illustrates come of the difficulties in the sampling. The *Bilim* salinities are below those of the other two CTD's, except in deepest water where the *Kolesnikov* salinity intercepted the *Bilim* salinity. The *Kolesnikov* salinity also is noisy. The *Akademik* data are uniformly above the *Bilim* salinities, and are much less noisy except for the cable noise described above. For comparison, this station can be compared with *Knorr* data added (Figure 20), comparing now at greater depths (deeper than 1400 db). Here, two *Knorr* stations (one in the east and one in the west), superimpose close to the *Bilim* data. The *Kolesnikov* suffers apparently from a depth dependency (discussed later), and the *Akademik* salinities are uniformly high.

5.2 Spike Removal and Filtering: Analysis of the data indicate that some filtering and spike removal was required. For all stations, filtering and spike removal was limited to levels greater than 500 db, to avoid filtering in the region of greatest gradients where such filtering could alter the structure of the profiles. Also, the filtering required is much less than the dynamic signature within these shallower regions, so filtering was not performed shallower than this level.

The filter used in all analyses was a tenth order Butterworth filter with a cutoff at 0.05 per meter. This filter was selected because of its lack of stopband and passband ripple. Although other filters could have been used, these one gave good performance without altering the shape of the profiles. In order to avoid phase shifts, the filtering was performed both forwards and backwards. However, this procedure gave unacceptable loss of data near the greater depths where the intercalibration occurred. To avoid this, the filter was run only in a forwards direction, and then shifted linearly to account for the filter loss at the end (40 db of data lost). Although the phase error is not linear with frequency for this filter, the narrow frequencies left in the data could be represented accurately by a simple frequency-independent shift. This was verified by repeated analysis both one way and forwards-and-backwards, and comparing the differences. The filter is described, for instance, in Oppenheim and Schafer (1975).

Only conductivity and temperature were filtered. Both were filtered with identical filters. The specific signal conditioning applied to each data set is described below.

Akademik data: The *Akademik* data were in good condition, except for some spikes noted at greater depths due to cable noise. These data were filtered in both temperature and conductivity. Although instead of filtering, the data could have been corrected by examining the modulo count and discarding any count increments greater than 24, the latter procedure would have been too time consuming for the small amplitude of spikes experienced. Butterworth filtering was effective at removing the spikes.

The shallow water spikes arising from ship motions influencing the seasonal thermocline were not removed. Their removal requires analysis of raw data, which was too time-consuming. These spikes will have to be removed at a later date.

Bilim data: These data were essentially noise-free, and hence were not filtered.

Kolesnikov data: These data were much noisier than the *Akademik* and *Bilim* data. Several types of filtering and corrections were made to these data.

The temperature data were examined in detail, and found to have large staircases (temperature sticking at a single value for up to 50 db). Although double-diffusion might provide similar ramps, they would not be expected to be of the same vertical scale, and would be seen in the other data (SBE-9), where they were absent. This staircase therefore was judged to be a faulty thermistor. To correct this error, the most prominent ramps (the largest at 9.015 degrees) were filtered by applying a linear correction over the length of this ramp. To filter out other staircases and to smooth out the discretization ramps, the temperature data were subjected below 500 db to a tenth order low-pass Butterworth filter, with a cutoff frequency at 0.05 per meter.

The conductivity data were fairly smooth, except for ripples having spatial scales of about 20-50 m, and amplitudes of about 0.01 mhos/m. Though smooth, the same filter was applied to these data to match that applied to the temperature data. In addition, the conductivity data also

flattened out a great depths, compared to the *Akademik* and *Bilim* data (e.g., Figure 19). To correct for this effect, the depth-dependent correction that the *Kolesnikov* scientists applied to the data was removed, using the formula:

$$C_n=C_m/(1+C_{kp}*p)$$

where the subscript n refers to the adjusted value, C is conductivity, m is the measured value, C_{kp} is the conductivity depth coefficient, and p is pressure in db. The *Kolesnikov* used a value of $5x10^{-5}$ for C_{kp}. To investigate the effect of C_{kp} on the slope of the conductivity data at depth, various values of C_{kp} were applied to the conductivity data after the correction was removed (C_{kp}=0). The values for C_{kp} used were $1.5x10^{-5}$, $2.5x10^{-5}$, and $3.5x10^{-5}$. Using several intercalibration stations with the *Kolesnikov* (including M10X45 and N30N45), the least error at depth occurred for values of about $1.5x10^{-5}$ for C_{kp} (Figures 21 and 22). This empirical depth dependency was derived for shallower water, but apparently was not optimized in deeper waters where the effect is greatest and where the intercalibration took place.

Parshin: No corrections or filtering were made to the *Parshin* data, because there were inadequate data with which to intercompare quantitatively. Intercomparison at one intercalibration station (Figure 23) shows the coarseness of the *Parshin* sampling, making detailed comparison impossible. Since the *Parshin* data are used only in shallow water where dynamic range is great, the lack of intercalibration is not limiting.

Piri Reis: The *Piri Reis* data were similar to the *Bilim's*, and required no filtering or spike removal.

5.3 Temperature Corrections: The filtered and de-spiked data were compared then compared to provide intercalibration offsets for all instruments for temperature. For temperature, corrections were derived from comparison at numerous intercalibration stations (Table 4). Based on these comparisons, the *Bilim*, *Piri Reis*, and *Akademik* temperatures were kept constant. The *Kolesnikov* temperature was reduced by 0.01°C, although the scatter about this value is about 0.005 °C. Lack of a clear time variation in temperature offset precluded more accurate correction.

5.4 Conductivity Corrections: The filtered and de-spiked data were then compared to provide intercalibration offsets for all instruments. Offsets were applied only to bin-averaged temperature and conductivity, not to salinity. For conductivity, the corrections were made after comparisons shown in Table 5. Since *Bilim* and *Akademik* conductivities were nearly equal (within approximately 0.005 S/m of each other), the other gauges were intercalibrated to these. The *Kolesnikov* conductivity was reduced by 0.023 S/m to provide best agreement and the *Piri Reis* was reduced by 0.01 S/m. The *Akademik* conductivity was reduced by 0.006 S/m, which is close to the accuracy of the present data.

5.5 Intercalibrated Data: After application of the conductivity and temperature filtering and offsets, the new salinity was computed. Also computed were potential temperature (Q) and potential density (s_q). Some examples of the intercomparisons of conductivity and salinity following these corrections are presented as Figures 24 through 35. For many of the intercalibration stations, the difference in intercalibrated temperatures is of the order of 0.005°C, and the salinity is 0.003 psu (e.g., Figures 24 and 25). For other stations, some difference in structure is apparent (e.g., Figure 26 of potential temperature), which is due to slight differences of position of the ships which in turn measure different thickness of bml. Other differences in temperature are as high as 0.005°C, such as in Figure 28. Finally, the greatest differences occur in intercomparisons with the *Kolesnikov*, which experienced significant drift in temperature (plus or minus 0.01°C). Comparisons between the *Kolesnikov* data and the *Bilim* or *Akademik* data show little consistency, with *Kolesnikov* salinity either above or below that at the other ships, depending on the date and location. Since no simple time variability to temperature changes was noted, no better correction could be added. Hence, the uncertainty in the measurements for the *Kolesnikov* is about 0.01°C. However, at some stations, the *Akademik*, *Kolesnikov*, and *Bilim* agree well, such as at Station N30N45 (Figures 34 and 35). Here, the agreement in temperature is better than 0.005°C, and the agreement in salinity is within 0.004 psu in general.

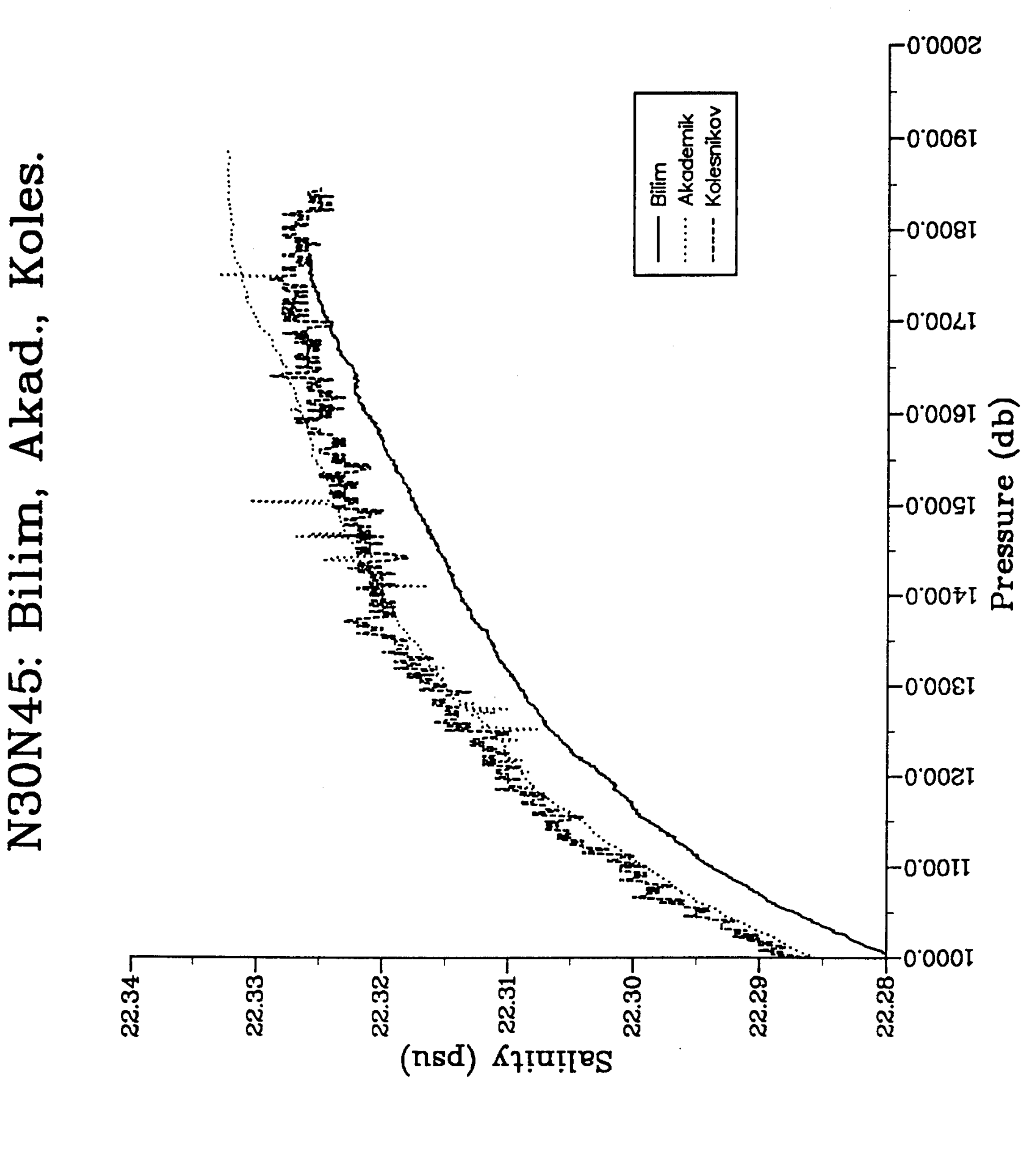


Figure 19: Comparison of non-intercalibrated salinity measurements at Station N30N45 for the *Bilim*, *Akademik*, and *Kolesnikov*. The overcorrection of the *Kolesnikov* data is depicted in the straightening of the salinity signal with depth, and crossing of the other two CTD's.

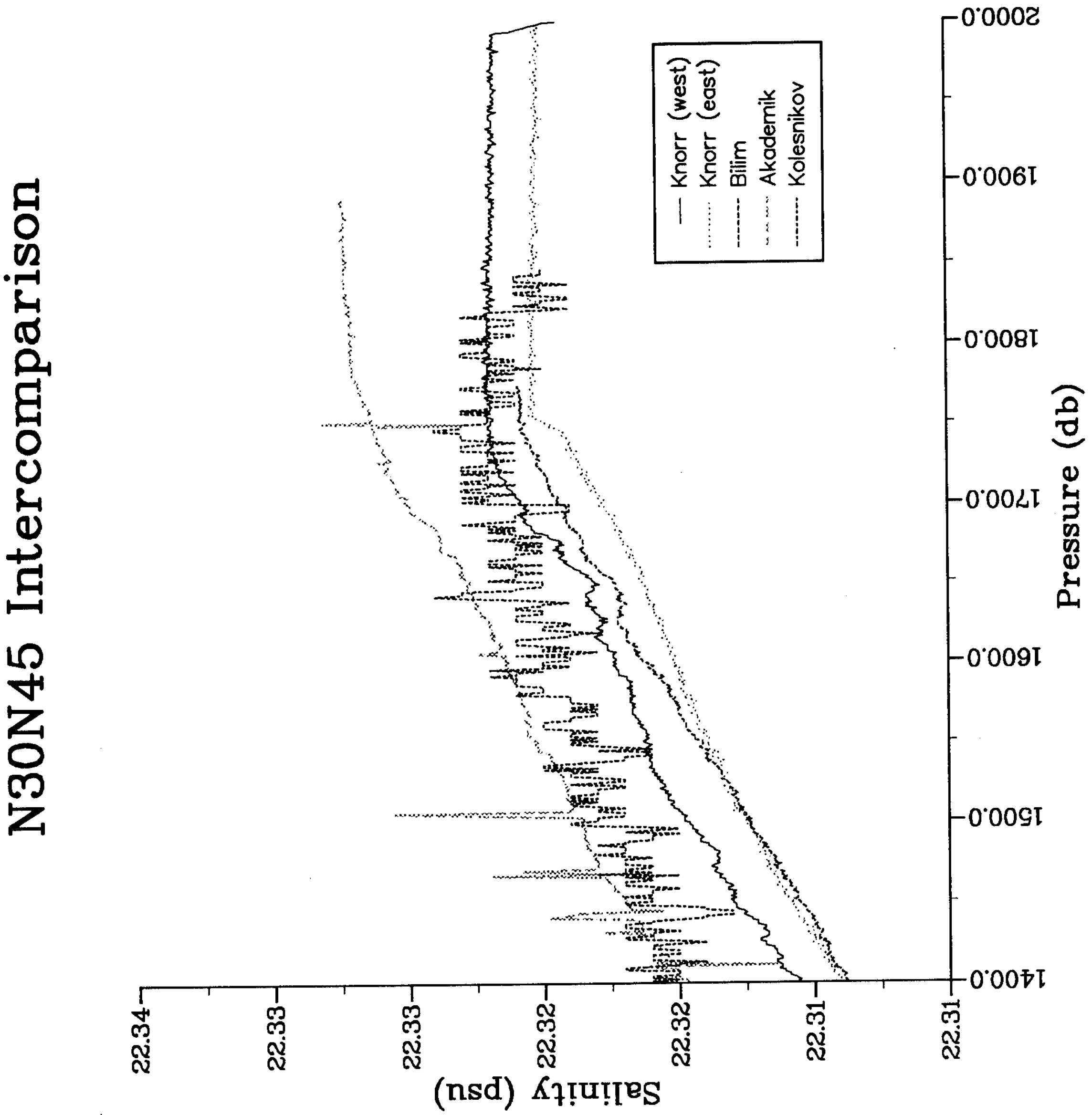


Figure 20: Same data as for Fig. 19, except for a more limited depth range (1400 to 2000 db), and adding the *Knorr* data. The *Bilim* data are the closest to the *Knorr* results; the *Akademik* CTD data are offset by about 0.01 psu higher compared to the *Knorr* and *Bilim* data.

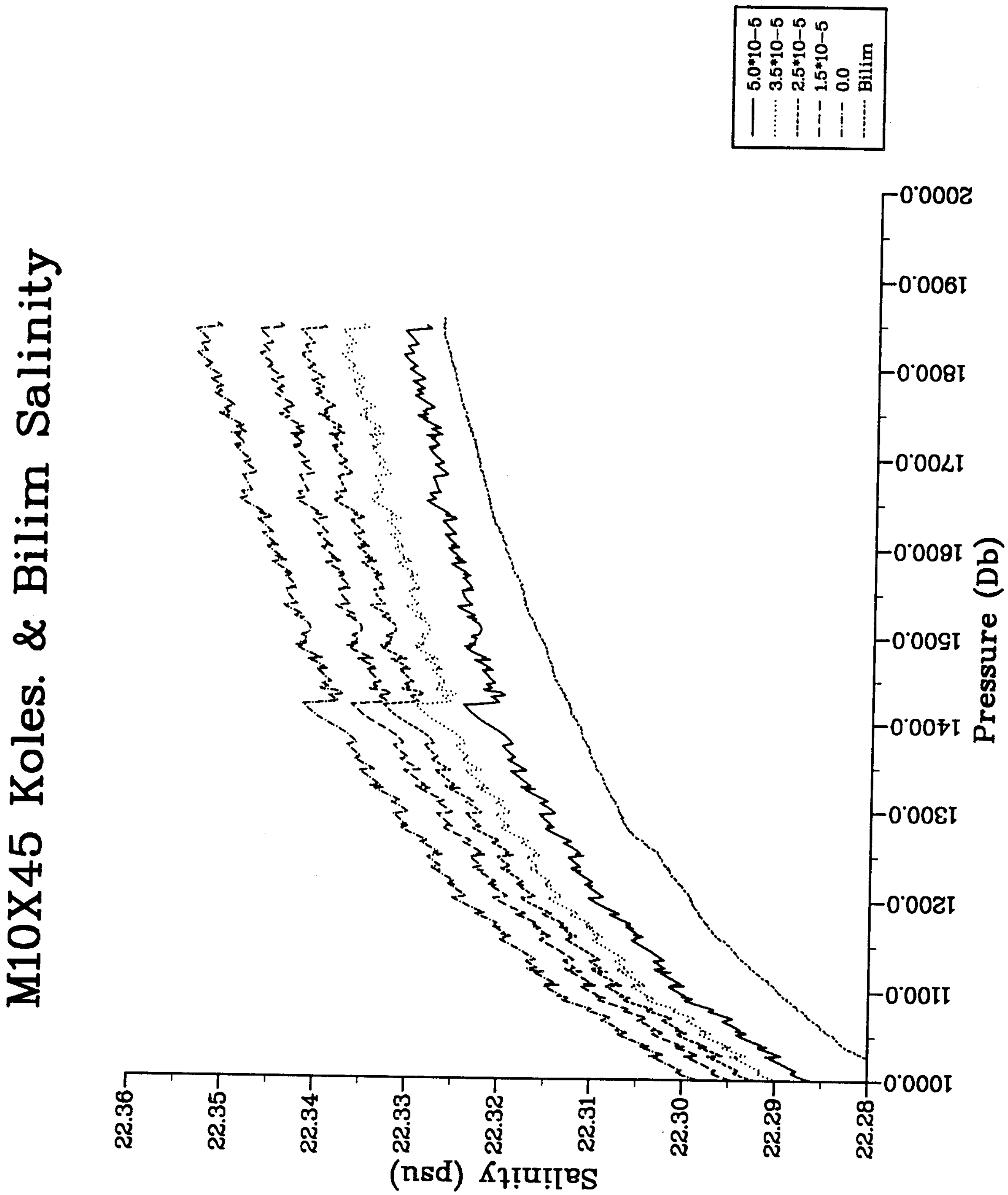


Figure 21: Comparison of salinity for the *Kolesnikov* and *Bilim* at station M10X45, varying the depth-dependent conductivity correction for the *Kolesnikov* CTD. The effect of the correction on the flattening of the salinity data at depth is shown.

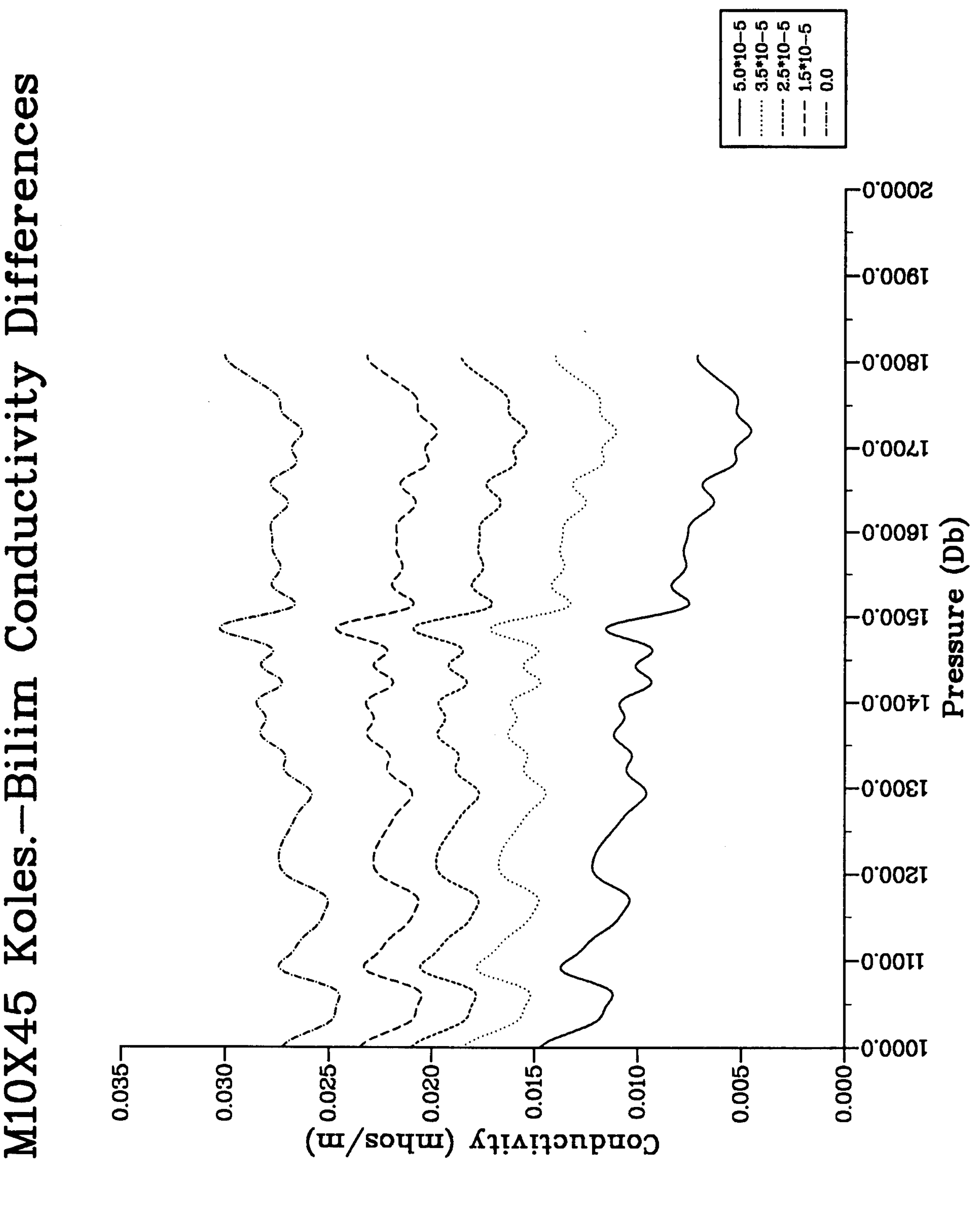


Figure 22: Differences in conductivities for the *Kolesnikov* and the *Bilim* at station M10X45, varying the depth-dependent conductivity correction for the *Kolesnikov* CTD. Although offsets are found in all sets, the error has no depth dependence for the case of the smallest depth correction.

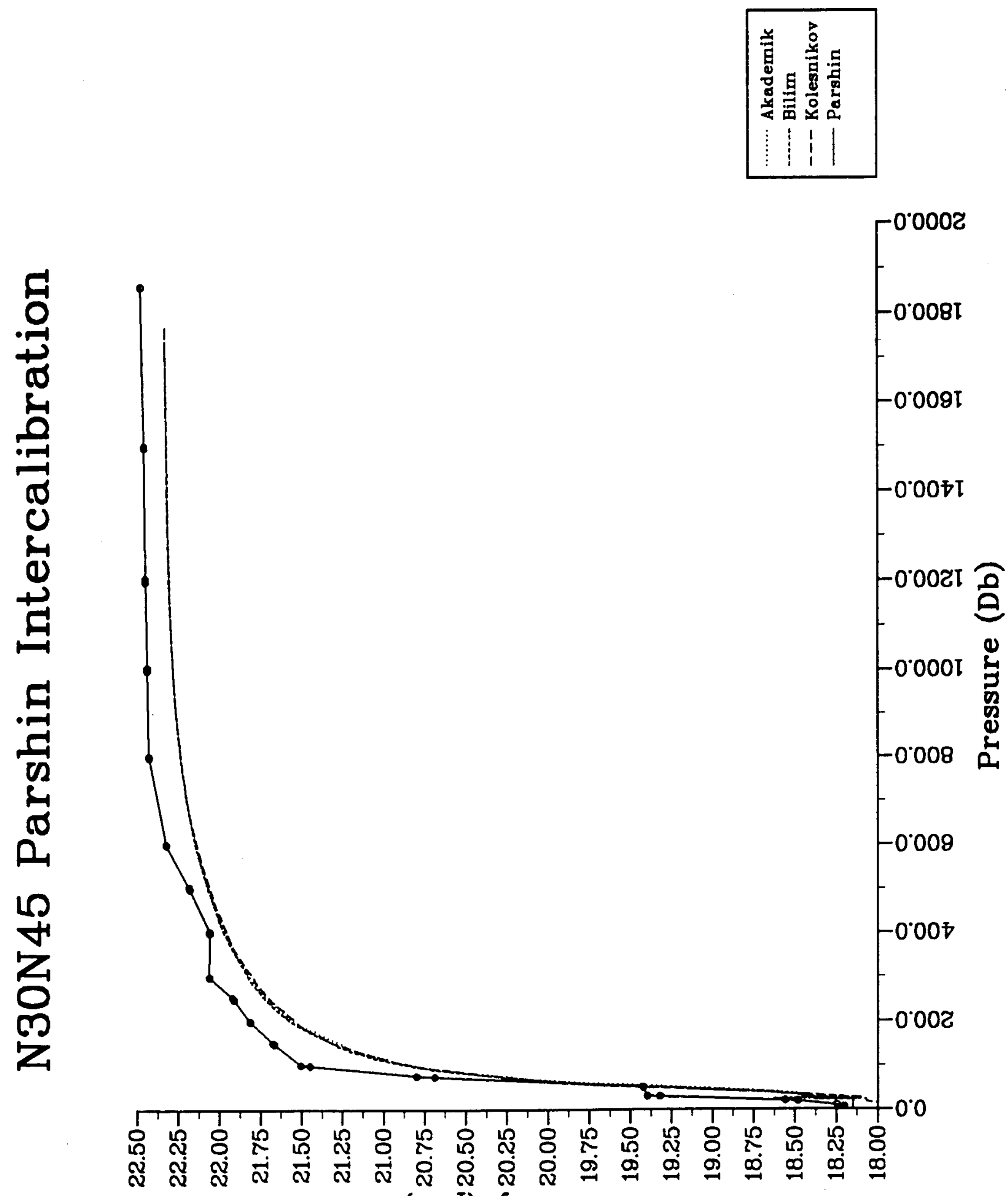


Figure 23: Intercomparison of the *Parshin* salinity data with *Akademik*, *Bilim*, and *Kolesnikov* data at station N30N45. Data points for the *Parshin* are shown as circles, indicating the coarseness of the sampling. Data points for other CTD's are not shown, since the sampling interval was too small. The coarseness of the *Parshin* data indicates that detailed intercalibration is impossible. Note that at this coarse depth scale, the three other ships produced data that are indistinguishable. Since most of the *Parshin* data are from shallow stations, this coarse sampling is less damaging.

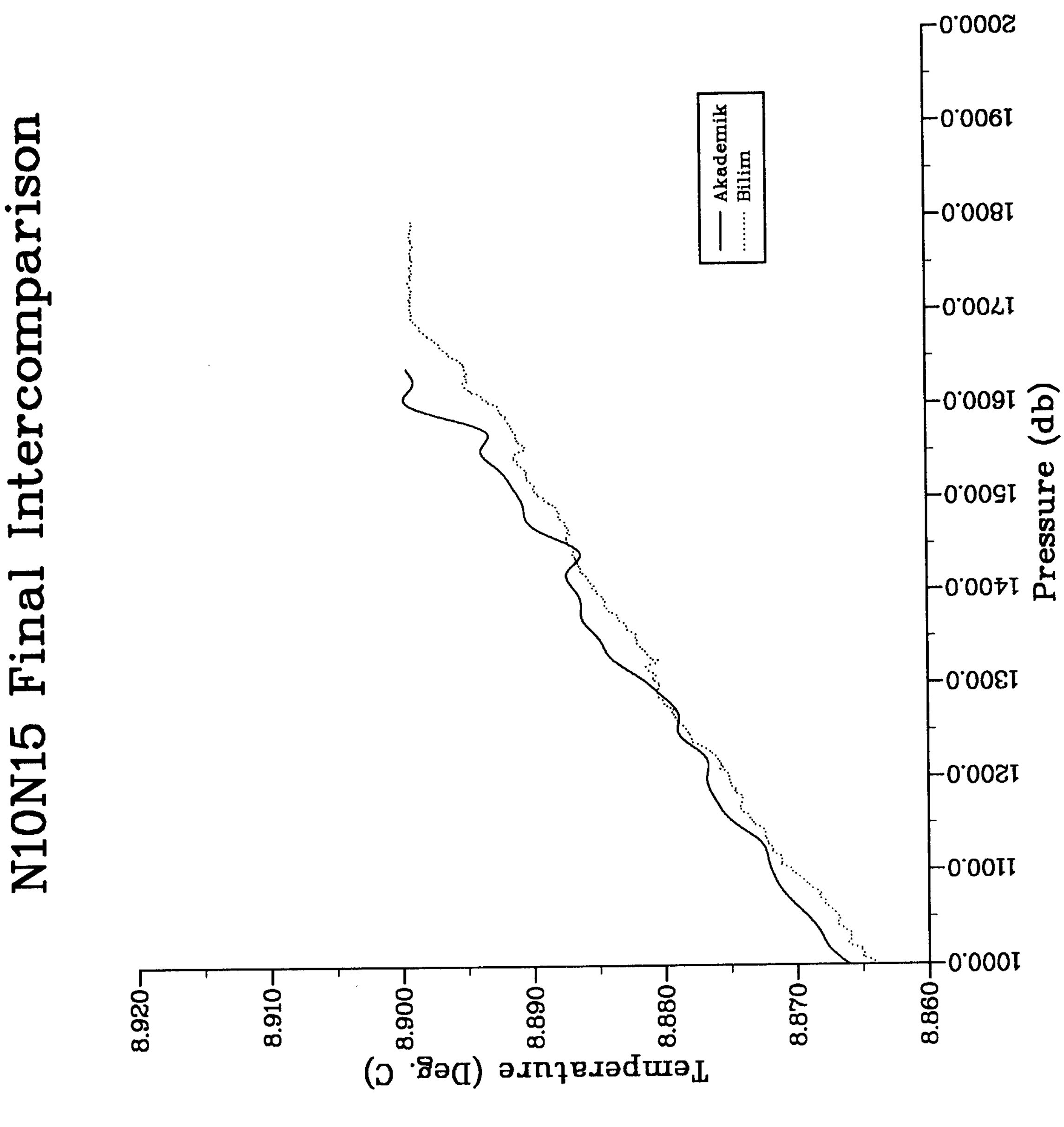


Figure 24: After intercalibration, the temperature data for the *Akademik* and the *Bilim* are approximately overlying at station N10N15. The low-frequency wiggles in the *Akademik* data are due to spiking and the effects of the low-pass filter. The temperatures are within 0.003°C or less throughout this depth range.

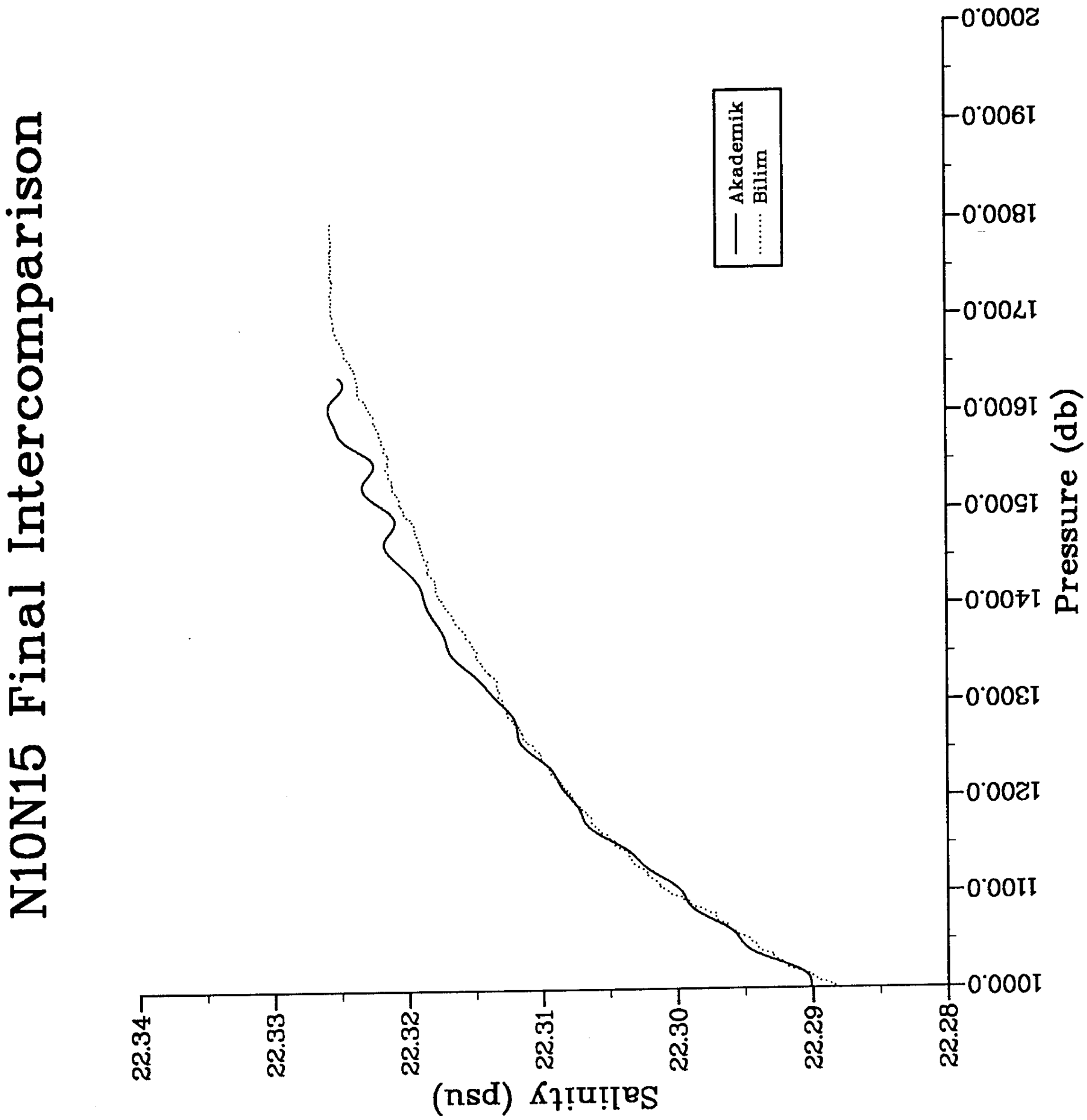


Figure 25: After intercalibration, the salinity data for the *Akademik* and the *Bilim* are approximately overlying at station N10N15. The low-frequency wiggles in the *Akademik* data are due to spiking in temperature and the effects of the low-pass filter. The salinities are within 0.003 psu or less throughout this depth range.

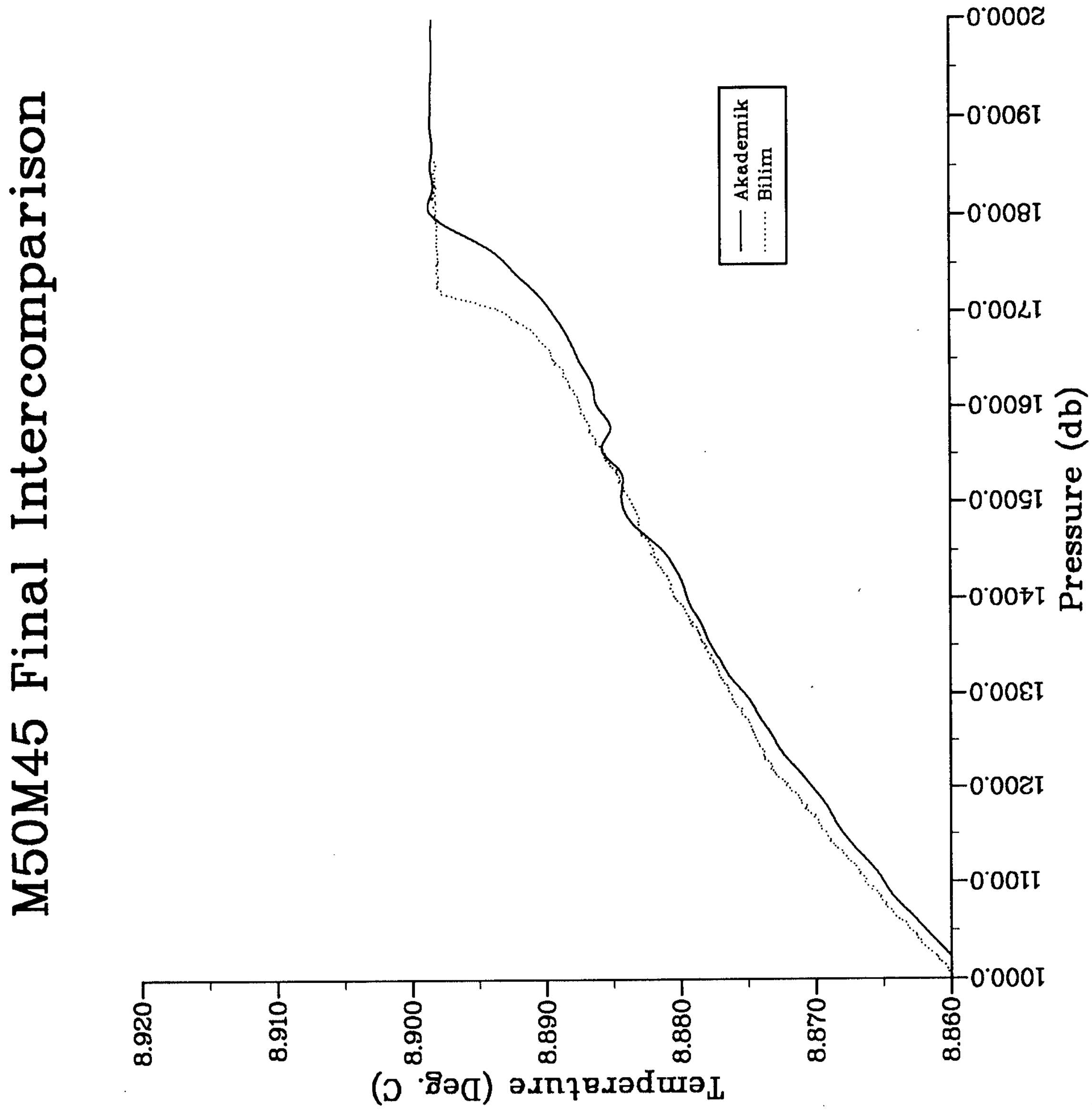


Figure 26: After intercalibration, the temperature data for the *Akademik* and the *Bilim* are approximately overlying at station M50M45. The low-frequency wiggles in the *Akademik* data are due to spiking and the effects of the low-pass filter. The temperatures are within 0.003°C or less over this depth range, and the temperatures in the bottom mixed layer differ by less than 0.001°C.

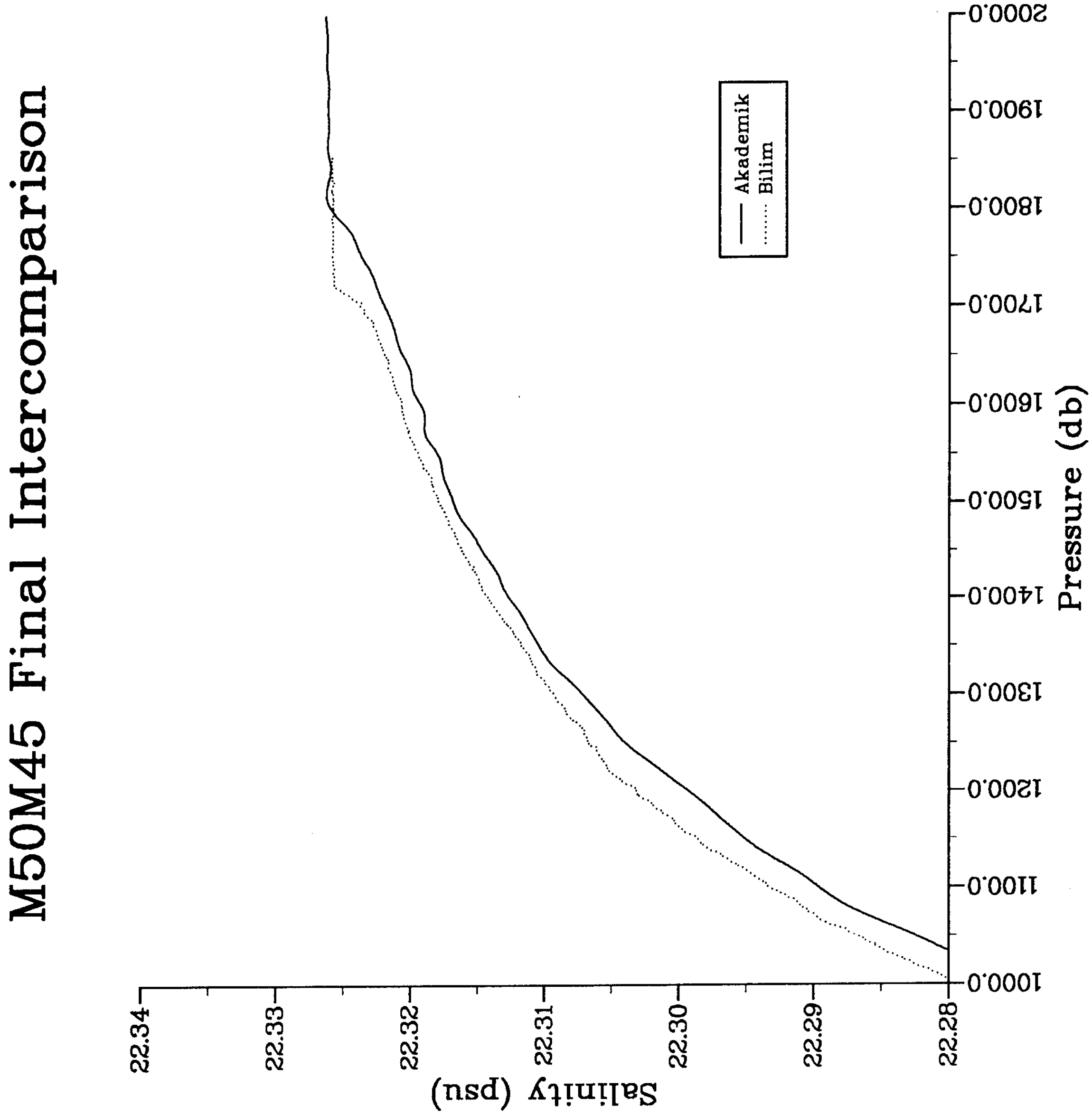


Figure 27: After intercalibration, the salinity data for the *Akademik* and the *Bilim* are approximately overlying at station M50M45. The low-frequency wiggles in the *Akademik* data are due to spiking in temperature and the effects of the low-pass filter. The salinities are within 0.003 psu or less throughout this depth range, and within 0.01 psu within the bottom mixed layer.

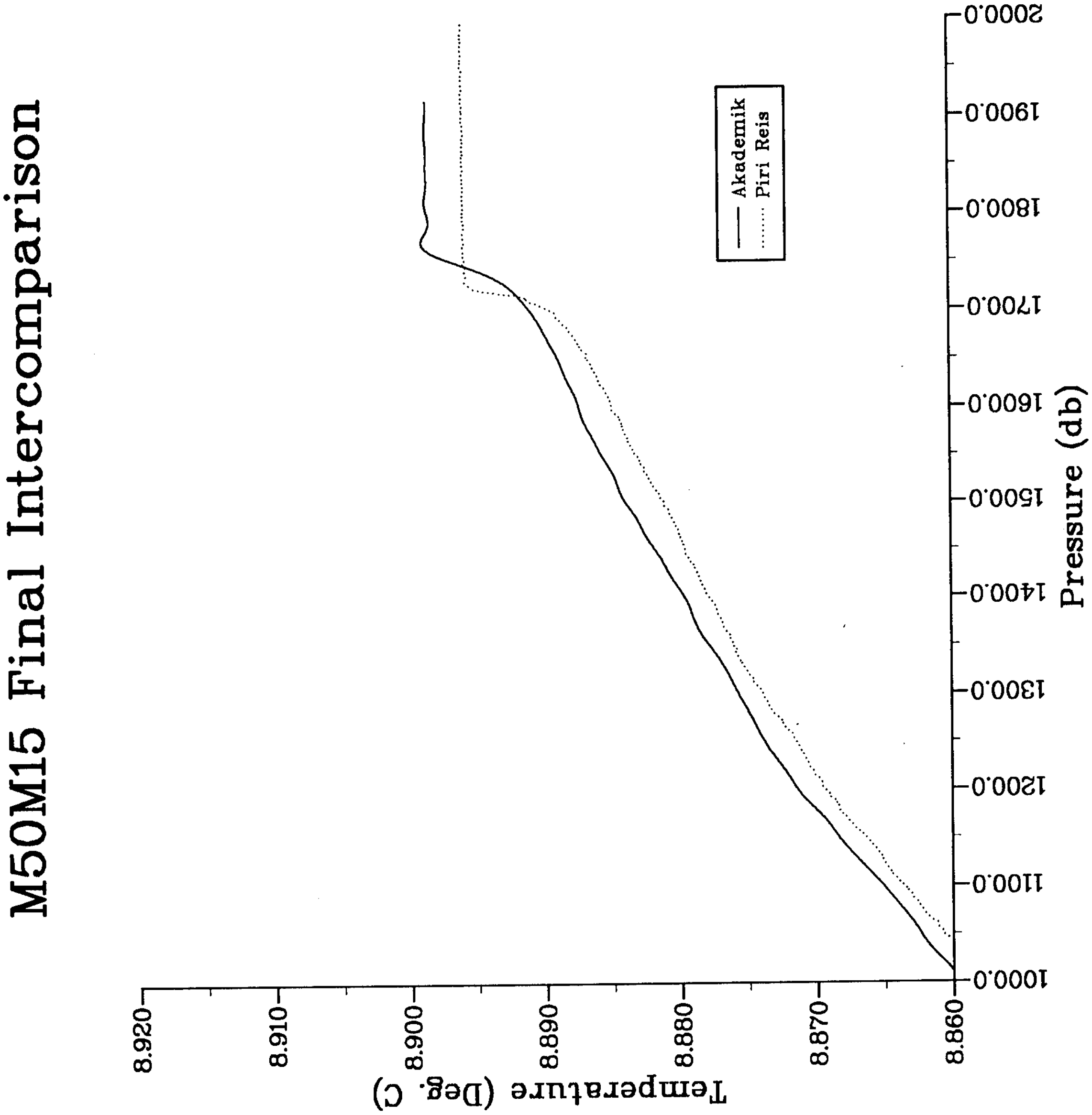


Figure 28: After intercalibration, the temperature data for the *Akademik* and the *Piri Reis* are approximately overlying at station M50M15. The temperatures are within 0.005°C or less throughout this depth range, and the temperatures in the bottom mixed layer are less than 0.003°C different.

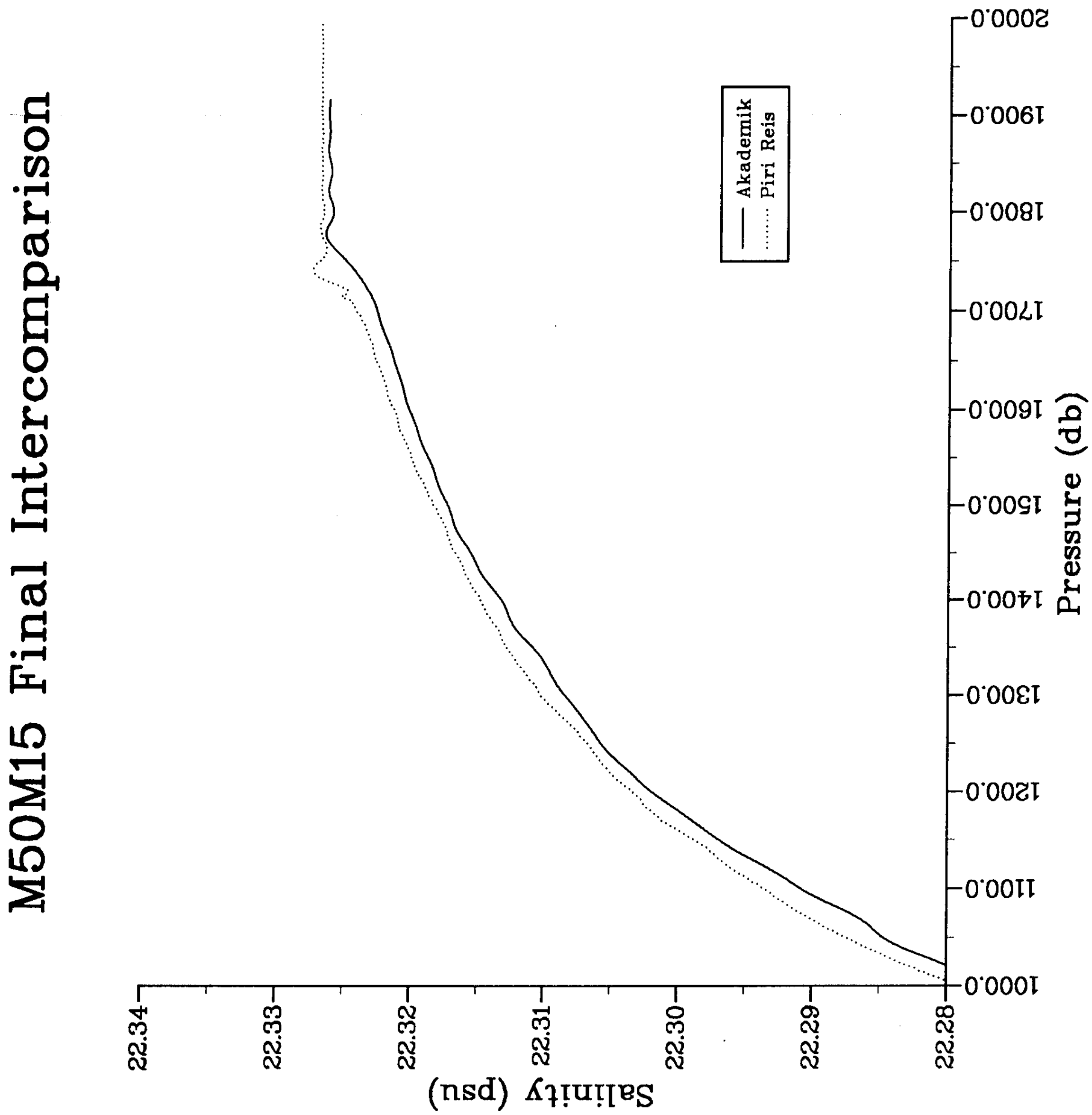


Figure 29: After intercalibration, the salinity data for the *Akademik* and the *Piri Reis* are approximately overlying at station M50M15. The salinities are within 0.003 psu or less throughout this depth range, and within 0.01 psu within the bottom mixed layer.

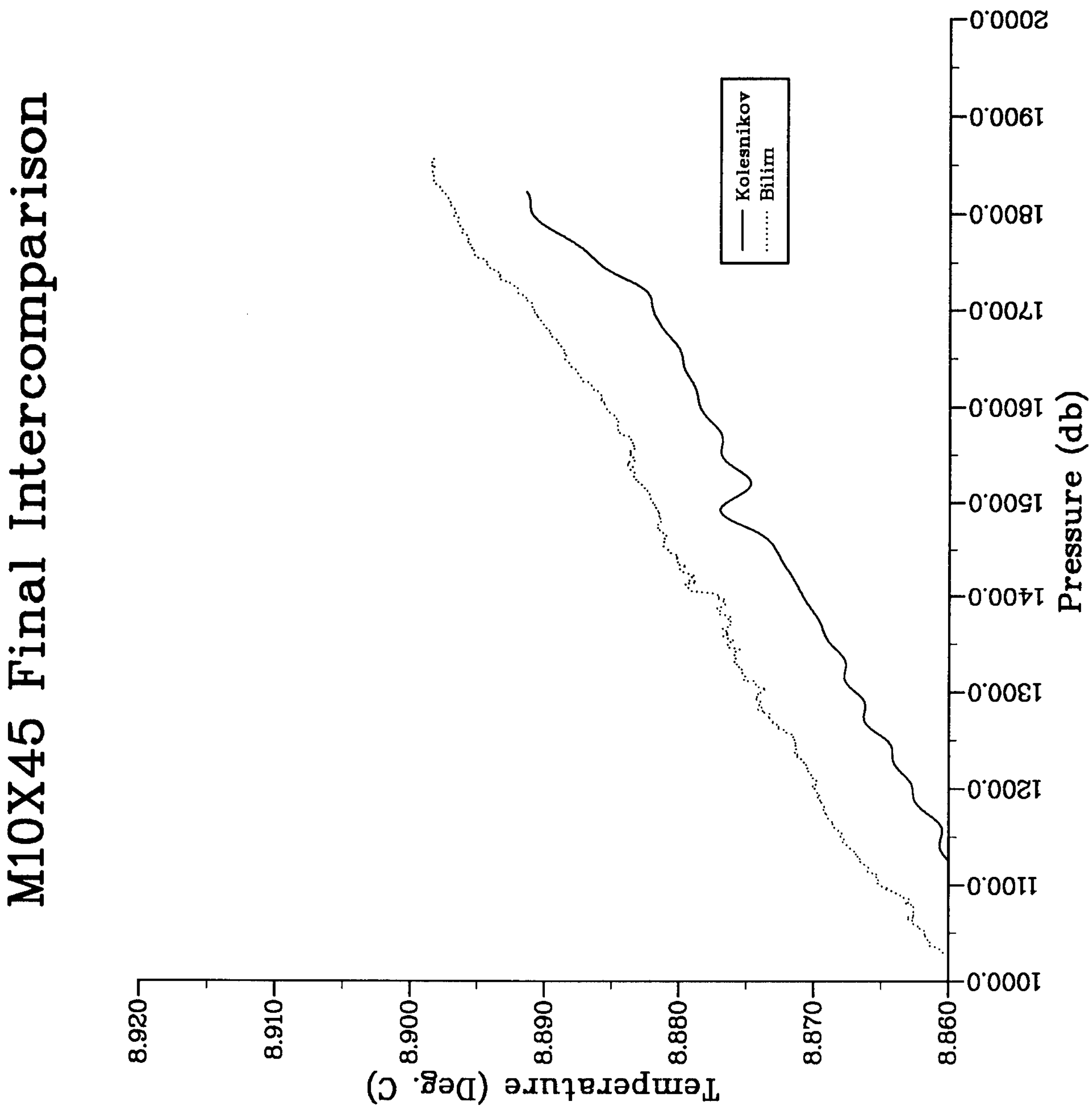


Figure 30: After intercalibration, the temperature data for the *Kolesnikov* and the *Bilim* are offset at station M10X45. The temperatures are within 0.01°C or less throughout this depth range. The temperature difference reflects the decision to apply one regional, average temperature correction to the *Kolesnikov* data, rather than a time-dependent value (see Fig. 7).

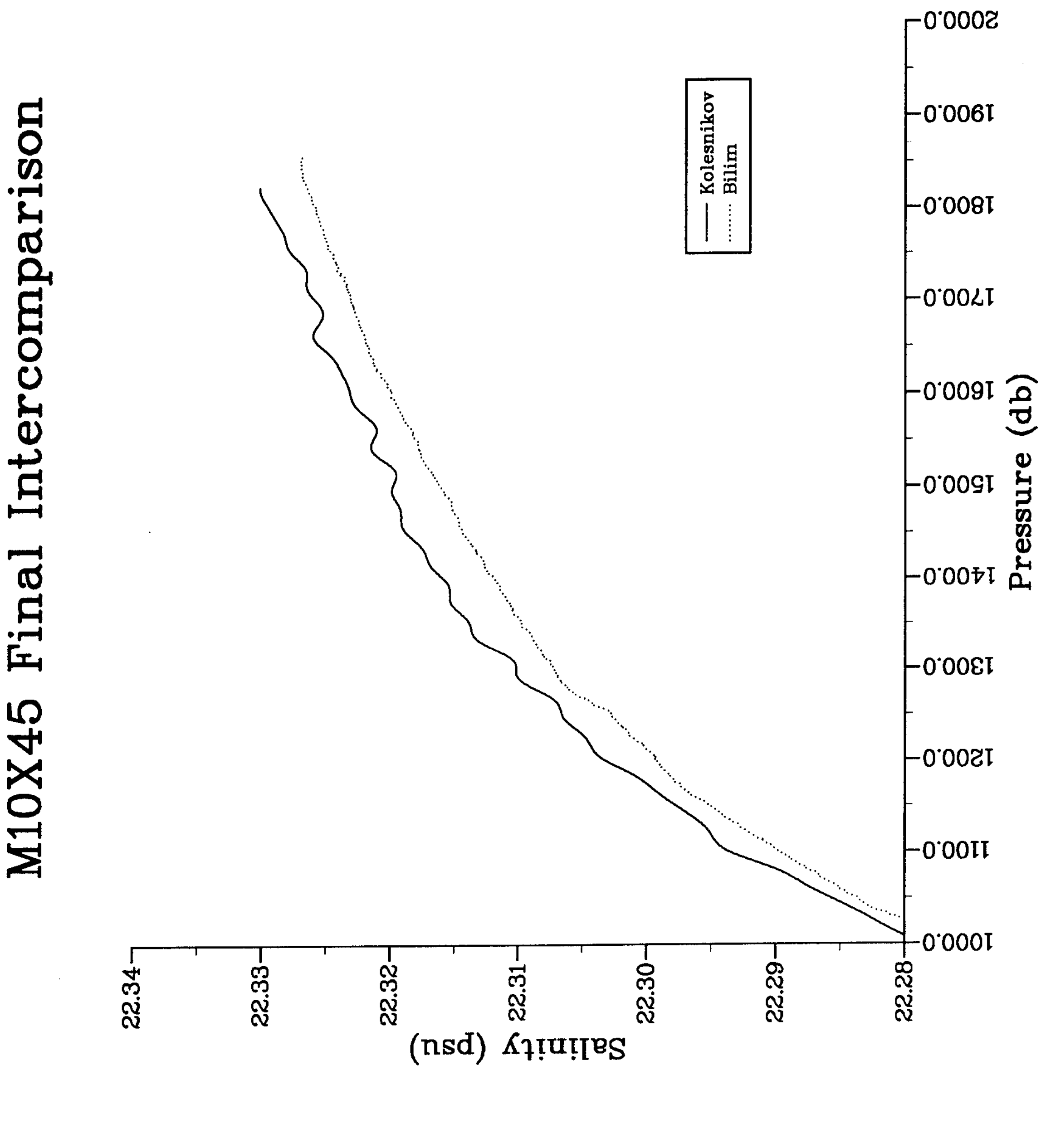


Figure 31: After intercalibration, the salinity data for the *Kolesnikov* and the *Bilim* are offset at station M10X45. The salinities are within 0.005 psu or less throughout this depth range. The differences reflect in part the temperature difference, and the depth-dependent conductivity correction.

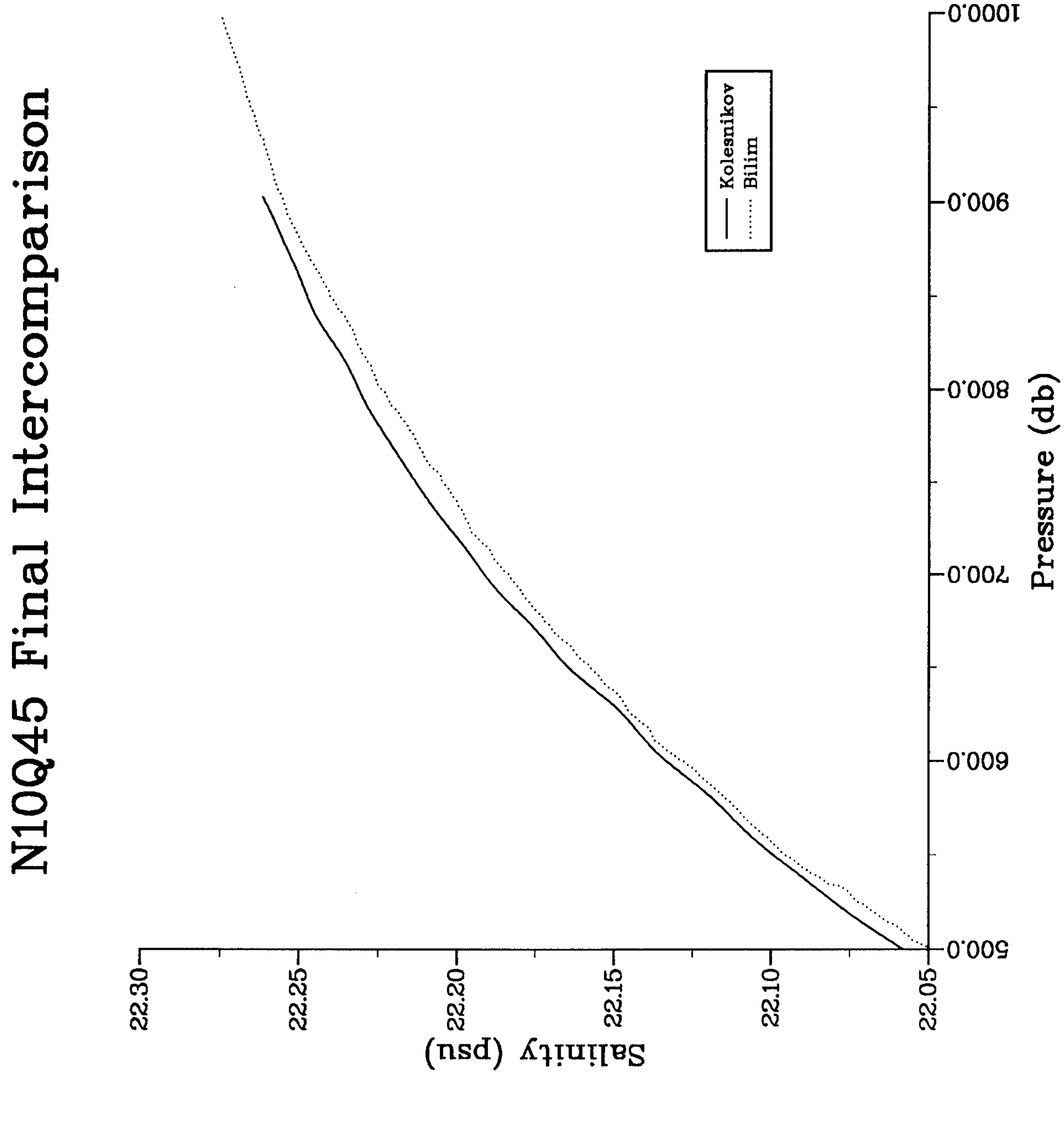


Figure 32: After intercalibration, the salinity data for the *Kolesnikov* and the *Bilim* are nearly overlapping at station N10Q45. The salinities are within 0.003 psu or less over this depth range. Contrast this excellent fit with Fig. 31 at another station.

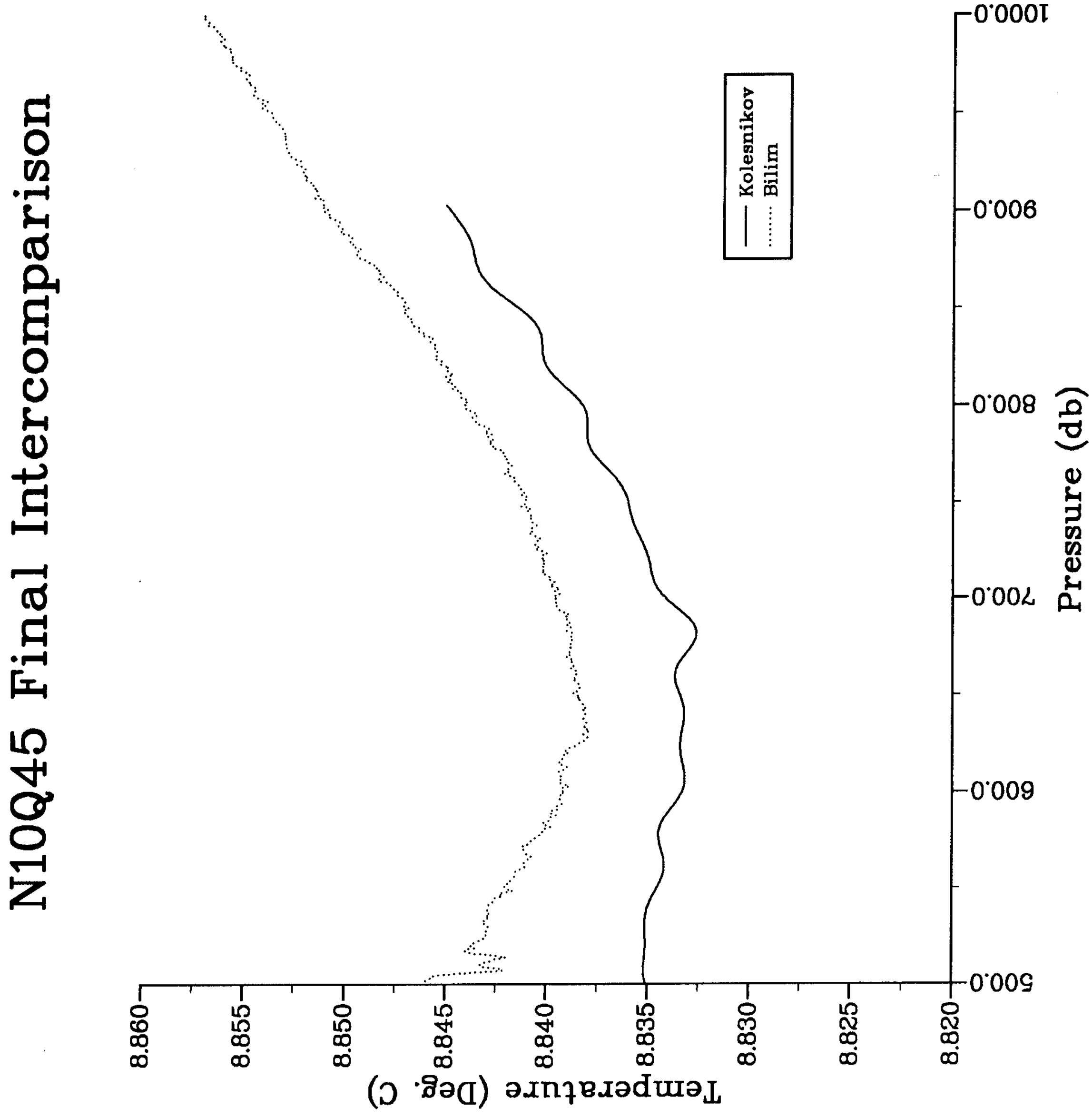


Figure 33: After intercalibration, the temperature data for the *Kolesnikov* and the *Bilim* are offset at station N10Q45. The temperatures are within 0.01°C or less over this depth range.

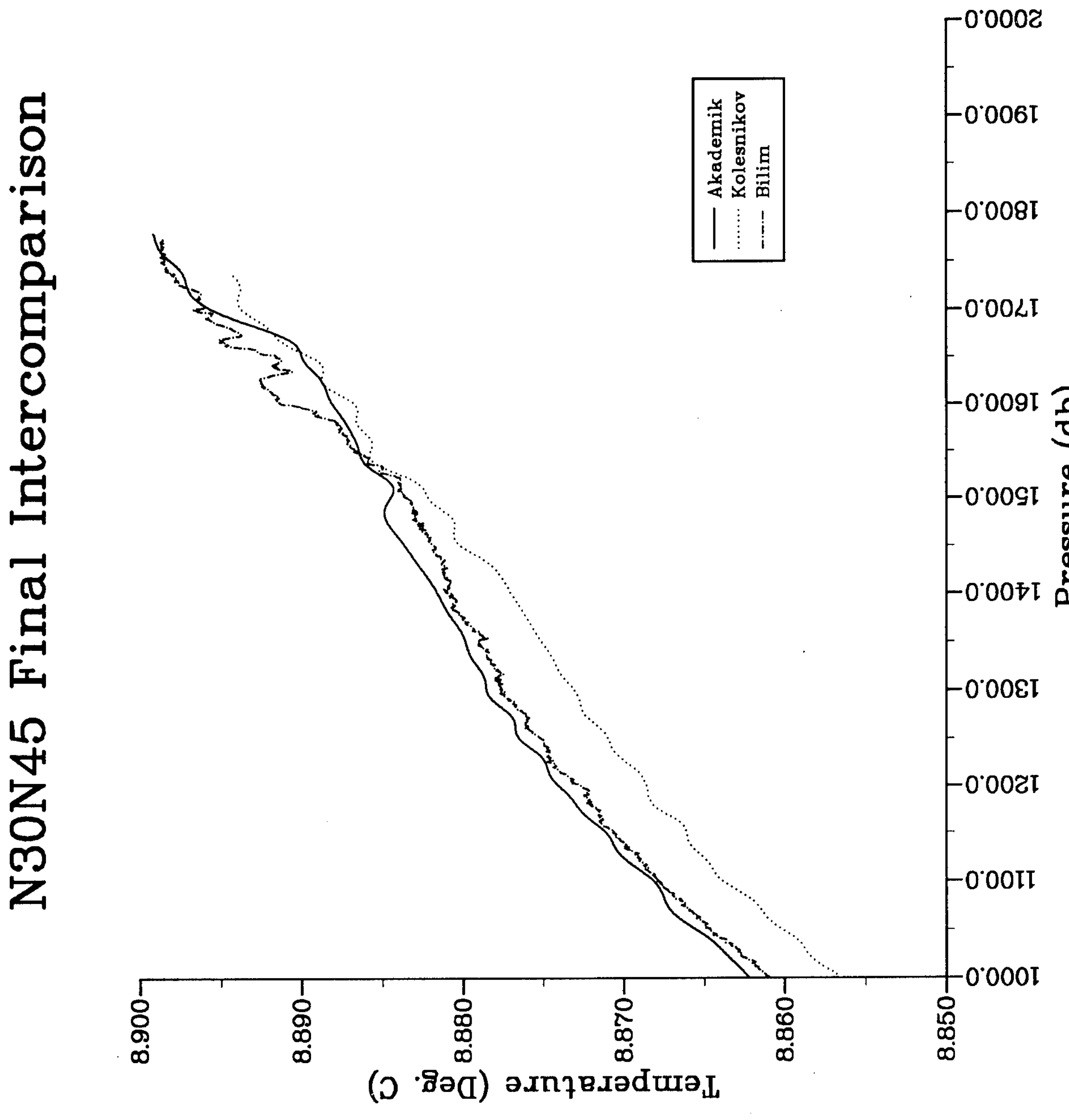


Figure 34: After intercalibration, a temperature comparison between the *Akademik*, *Kolesnikov*, and *Bilim*, at station N30N45. The temperatures are within 0.005 except for the *Kolesnikov* in the shallower portion of the section.

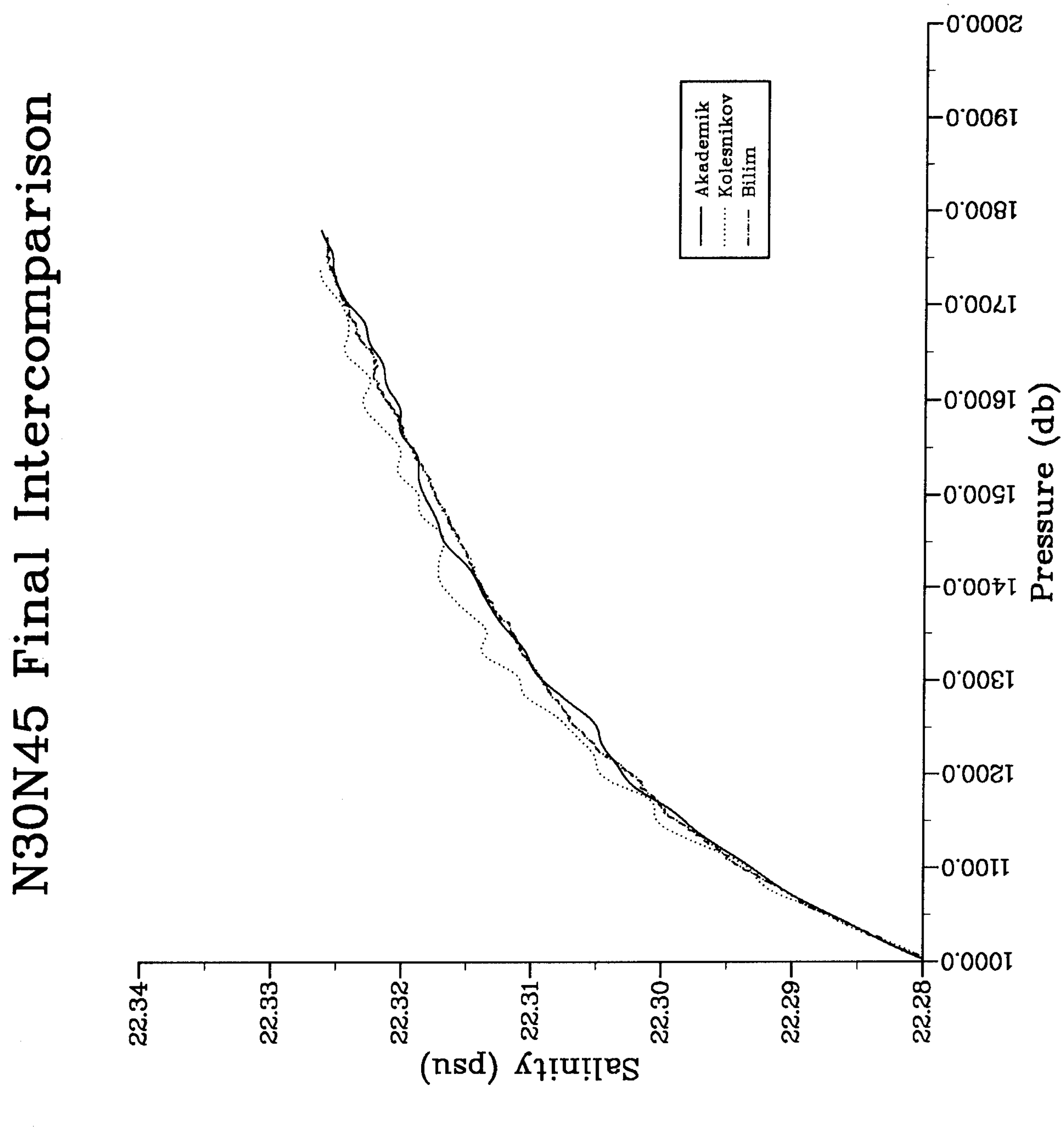


Figure 35: After intercalibration, a salinity comparison between the *Akademik*, *Kolesnikov*, and *Bilim* at station N30N45. The salinities are all within 0.005 psu. The wiggles in the *Kolesnikov* salinity reflect discontinuities in the temperature data for the CTD.

TABLE 4
TEMPERATURE DIFFERENCES (1200-1400 db)
(°C)

Station Code (Table 3)	Akd.-P. Reis	Akd.-Bilim	Bilim-P.Reis	Bilim-Kolesnikov before Filtering	Bilim-Kolesnikov after Filtering	Akd.-Kolesnikov before Filtering	Akd.-Kolesnikov after Filtering
226				-0.023±0.001	-0.023±0.0008		
266				-0.003±0.001	-0.003±0.0007		
50	-0.002±0.004						
70	-0.002±0.006	-0.001±0.0006	+0.003±0.0003*				
82		0.008±0.0006					
83						-0.005±0.0015	-0.005±0.0003
101		0.001±0.0004		-0.006±0.001	-0.006±0.0003	-0.005±0.0010	-0.005±0.0003
165(B)/173(K)				-0.021±0.001	-0.021±0.0007		
203(B)/215(K)				-0.009±0.001	-0.009±0.0006		
24(R)/42(B)			-0.002±0.001				
247(K)/248(B)							
147(K)/148(B)					-0.020±0.0006		
					-0.012±0.0006		

* Station 50 is used for P. Reis

TABLE 5
CONDUCTIVITY DIFFERENCES (1200-1400 db)
(S/M)

Station Code (Table 3)	Akd.-P. Reis	Akd.-Bilim	Bilim-P.Reis	Bilim-Kolesnikov before Filtering	Bilim-Kolesnikov after Filtering	Akd.-Kolesnikov before Filtering	Akd.-Kolesnikov after Filtering
226				-0.014±0.002	-0.025±0.0006		
266				-0.011±0.001	-0.022±0.0009		
50	-0.005±0.001						
70	-0.006±0.001	0.003±0.001	-0.009±0.0004				
82		0.008±0.001					
83						-0.003±0.001	-0.013±0.001
101		0.007±0.0008		-0.011±0.001	-0.021±0.0008	-0.004±0.001	-0.015±0.001
165(B)/173(K)				-0.012±0.001	-0.023±0.0010		
203(B)/215(K)				-0.012±0.001	-0.025±0.0004		
24(R)/42(B)			-0.013±0.0003				
247(K)/248(B)					-0.021±0.0006		
147(K)/148(B)					-0.025±0.0010		
		0.006±0.001	-0.010±0.0003		-0.022±0.0007		

5.6 Salinity Bottle Samples for Titration: Water samples were obtained at each cast aboard the ships. These bottle samples were intended for intercalibration purposes. However, the sampling procedure was flawed in that the cruise plan did not specify the type of bottle to be used, nor the depths at which samples were to be taken. Consequently, the data from the Turkish ships and the Bulgarian ship had to be discarded. The bottles used were made of plastic, and evaporation occurred in the bottles before their analysis at Woods Hole.

The samples taken aboard the *Parshin* and the *Kolesnikov* were made with standard glass bottles, and hence were of high quality except when the sampling rosette leaked. However, the *Parshin* samples were taken at shallow depths where variability is high, and hence were of no use in intercalibration between ships. The *Kolesnikov* data were the best of the group (Table 6). In general, the bottle samples disagreed with the *Kolesnikov* conductivity measured by the Istok CTD by about 0.025 S/m. This value is about 0.008 S/m less than that applied based on intercomparison of the profiles at intercalibration stations. This difference is consistent with the uncertainty resulting from the temperature drift.

6. INTERCALIBRATED DATA ANALYSIS

Using available intercalibrated data, various calculations were made to illustrate different aspects of the physical oceanography of the Black Sea. These calculations were compared to subjective analyses of hydrophysical fields to assure the validity of the computer analysis. Computer analysis was completed on a SUN SparcStation II, using MATLAB and UNIMAP software licensed to the Woods Hole Oceanographic Institution.

6.1 Dynamic Height: Calculations of dynamic height were made using standard analysis techniques. All calculations were referenced to the 900 db level. Below this level, prior calculations have shown dynamic height contributions to be on the order of mm's. Neglect of lower levels does not affect the interpretation of these calculations. The dynamic topography at 5 db (Figure 36) depicts the major circulation within the Black Sea, including the rim current, the major sub-basin scale cyclones, plus a series of anticyclones, some permanent, rimming the basin. Additional dynamic topography plots are included in Annex V.

6.2 Horizontal and vertical sections: Horizontal and vertical sections of temperature, salinity, and density were made along several transects across the Black Sea to describe briefly the distribution of these properties. Results are provided in Annex V.

7. RECOMMENDATIONS FOR FUTURE

7.1 Sevastopol Workshop: February 1992

An interdisciplinary workshop will be held in Crimea, Ukraine, in February 1992. The workshop will be held to perform the complete intercalibration of biological and chemical data, and to integrate those data with the physics. We recommend that the following take place:

- Adoption of the simpler numerical scheme identifying stations instead of the more cumbersome scheme adopted during the cruise.
- That technical reports be issued on the intercalibration of the biological and chemical data.
- That the full data sets be placed on a common computer, and analyzed jointly to examine for inter-relationships in an interdisciplinary sense.

7.2 Publications

Joint publications for the HYDROBLACK '91 material will follow the general guidance of the Cruise Planning Document (see Annex II). In general, we expect the publications to be in International as well as National journals, and will follow in several general areas:

- Basin-wide CTD results
- Coastal ocean physics and site-specific hydrography

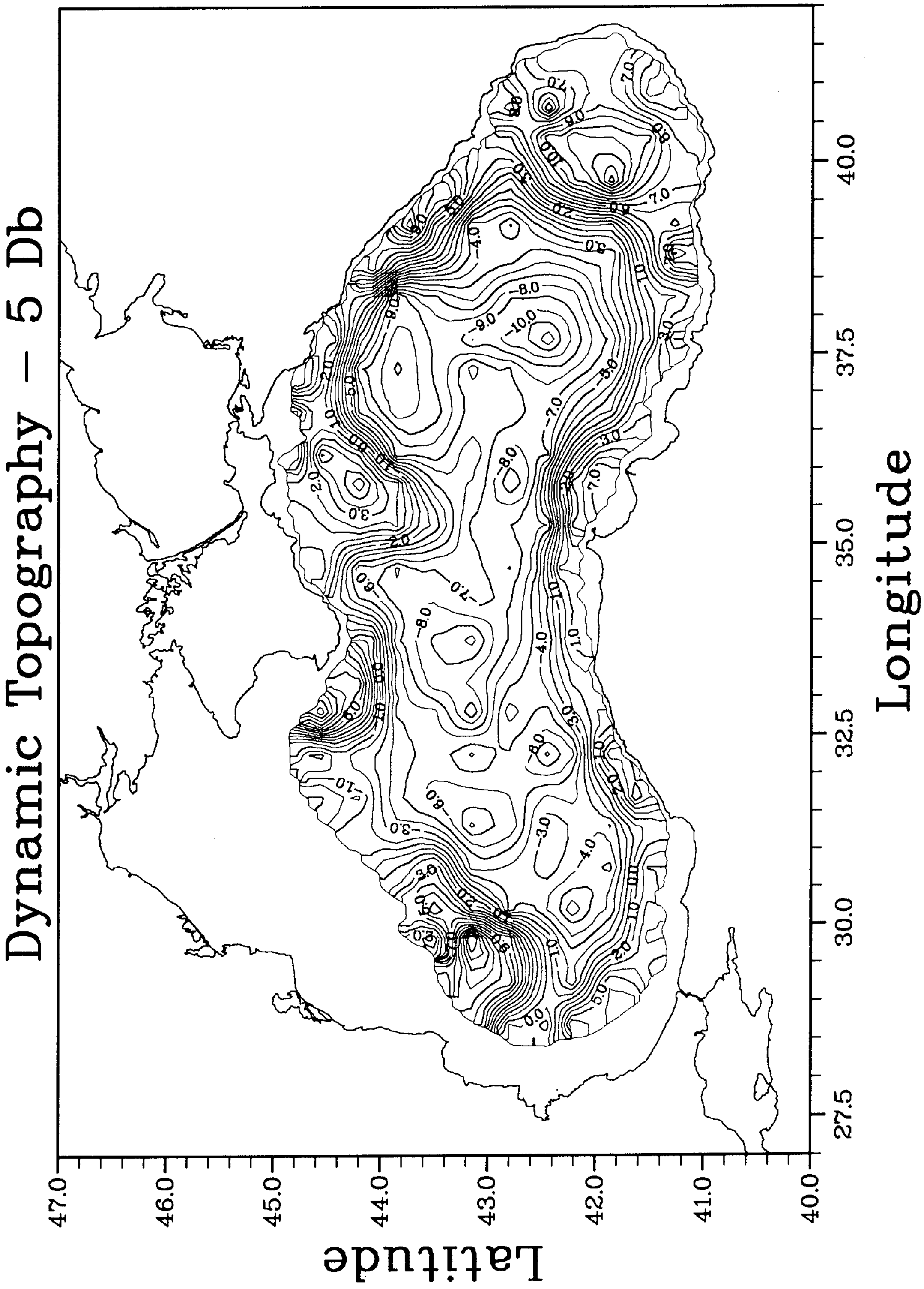


Figure 36: Dynamic topography for stations having depths exceeding 900 m. The dynamic topography is for 5 db level, referenced to 900 db.

TABLE 6

WATER BOTTLE SAMPLE RESULTS: IN SITU AND TITRATED

	STATION	PRESSURE	CTD cond	titr. cond	titration(ckp)	ctd-titr. cond
1	M50V45	1046.000	25.01200	25.00300	24.9991	-0.0129
2	M50W45	1042.000	25.00900	25.00410	25.0002	-0.0088
3	M30X15	1006.000	24.98800	24.98050	24.9767	-0.0113
4	M30X45	756.000	24.80400	24.78980	24.7870	-0.0170
5	M10Y15	767.000	24.80400	24.79170	24.7888	-0.0152
6	M10Y45	509.000	24.53300	24.50960	24.5077	-0.0253
7	L50Z15	1110.000	25.04500	25.04200	25.0378	-0.0072
8	M30Z15	513.000	24.53300	24.52150	24.5196	-0.0134
9	M40Z00	759.000	24.80700	24.79750	24.7947	-0.0123
10	M30Y45	403.000	24.37400	24.36320	24.3617	-0.0123
11	M30Y15	1524.000	24.68900	25.22640	25.2206	0.0000
12	M50Y45	760.000	24.81800	24.81220	24.8094	-0.0086
13	M50X45	1008.000	24.98500	25.00650	25.0027	0.0177
14	M50X15	1018.000	24.99900	24.97880	24.9750	-0.0240
15	N10X15	808.000	24.85100	24.83720	24.8342	-0.0168
16	N24X35	1165.000	25.07300	25.06280	25.0584	-0.0146
17	N30W45	1019.000	24.99300	24.98400	24.9802	-0.0128
18	N50W45	762.000	24.80900	24.80530	24.8025	-0.0065
19	P10W15	762.000	24.80700	24.78020	24.7774	-0.0296
20	P10W15	1013.000	24.99600	24.98950	24.9857	-0.0103
21	P10W15	1731.000	25.31890	25.31250	25.3059	-0.0130
22	N50W15	810.000	24.85600	24.84280	24.8398	-0.0162
23	N30W15	508.000	24.56300	24.59230	24.5904	0.0274
24	N10W45	762.000	24.81800	24.81470	24.8119	-0.0061
25	N10W15	906.000	24.93300	24.92620	24.9228	-0.0102
26	N30V45	1520.000	25.23200	25.22650	25.2207	-0.0113
27	N10V15	2027.000	25.43400	24.98880	24.9812	0.0000
28	N10V45	1032.000	25.00100	25.42460	25.4207	0.0000
29	N30V15	408.000	24.41200	24.39860	24.3971	-0.0149
30	N30V15	1015.000	24.98800	24.96850	24.9647	-0.0233
31	N50V45	605.000	24.67500	24.66860	24.6664	-0.0086
32	N50V15	504.000	24.56800	24.57620	24.5743	0.0063
33	N50T45	759.000	24.82300	24.81850	24.8157	-0.0073
34	N30T45	490.000	24.40600	24.43360	24.4318	0.0258
35	N30T15	1212.000	25.09200	25.08080	25.0762	-0.0158
36	N50T15	1015.000	24.99000	24.97710	24.9733	-0.0167
37	P10T45	1519.000	25.23200	25.20490	25.1992	-0.0328
38	P10V15	1019.000	24.99900	24.99460	24.9908	-0.0082
39	P10V45	1831.000	25.36000	25.35430	25.3473	-0.0127
40	P28V45	749.000	24.80700	24.79700	24.7942	-0.0128
41	P30V15	507.000	24.53800	24.52910	24.5272	-0.0108
42	P45V05	608.000	24.68100	24.67860	24.6763	-0.0047
43	P30T45	913.000	24.93500	24.92110	24.9177	-0.0173
44	P10T15	808.000	24.84800	24.83950	24.8365	-0.0115
45	P30T15	711.000	24.77100	24.55140	24.5488	0.0000
46	P30S45	1022.000	24.98800	24.96240	24.9586	-0.0294
47	P10S45	1822.000	25.35500	25.34900	25.3421	-0.0129
48	N50S45	505.000	24.52200	24.51830	24.5164	-0.0056
49	N30S45	1052.000	25.00400	24.99450	24.9906	-0.0134
50	N30S15	1416.000	25.18200	25.14980	25.1445	-0.0375
51	N50S15	810.000	24.83700	24.82700	24.8240	-0.0130
52	P10S15	909.000	24.91100	24.90110	24.8977	-0.0133
53	P39S15	505.000	24.54900	24.54110	24.5392	-0.0098
54	P36R45	757.000	24.81500	24.80700	24.8042	-0.0108
55	P10R45	2029.000	25.43400	25.43060	25.4229	-0.0111
56	P10R15	1050.000	25.01200	25.00810	25.0042	-0.0078

	STATION	PRESSURE	CTD cond	titr. cond	titration(ckp)	ctd-titr. cond
57	N50R15	1515.000	25.23200	25.23120	25.2255	-0.0065
58	N50R45	813.000	24.85600	24.85310	24.8501	-0.0059
59	N30R45	1011.000	25.99000	24.98680	24.9830	0.0000
60	N10R15	1015.000	24.99000	24.98570	24.9819	-0.0081
61	N10R15	1523.000	25.22900	25.22350	25.2177	-0.0113
62	N10R15	2044.000	25.43700	25.42180	25.4140	-0.0230
63	N10Q45	906.000	24.92500	24.91600	24.9126	-0.0124
64	N30R15	1029.000	25.00400	24.99230	24.9884	-0.0156
65	N30Q45	1315.000	25.14400	25.13070	25.1257	-0.0183
66	N30Q45	1723.000	25.31900	25.31600	25.3095	-0.0095
67	N50Q15	1416.000	25.18500	25.18270	25.1774	-0.0076
68	N50Q15	1877.000	25.37400	25.36560	25.3585	-0.0155
69	P10Q15	1039.000	24.99600	24.98520	24.9813	-0.0147
70	P25Q08	406.000	24.37900	24.38290	24.3814	0.0024
71	P07Q45	883.000	24.91400	24.90080	24.8975	-0.0165
72	N30Q15	507.000	24.56300	24.56050	24.5586	-0.0044
73	N30P45	1516.000	25.23200	25.22640	25.2207	-0.0113
74	N30P45	1925.000	25.39300	25.39050	25.3832	-0.0098
75	N50P45	1040.000	25.00100	24.99090	24.9870	-0.0140
76	N50P15	1211.000	25.09400	25.09380	25.0892	-0.0048
77	N30P15	911.000	24.92700	24.92550	24.9221	-0.0049
78	N30N45	1619.000	25.27500	25.26640	25.2603	-0.0147
79	N50N45	1040.000	25.00400	24.99930	24.9954	-0.0086
80	N30N15	1425.000	25.19600	25.19310	25.1877	-0.0083

Interdisciplinary relationships between the different data sets: such as oxygen distribution, hydrogen sulfide distribution, suboxic zones, etc. and their relationship to the physics and biology.

The publications should be sent to the Steering Committee office, to be given a publication number for the Cooperative Marine Science Program on the Black Sea, and to be listed in summaries of Cooperative Program results. Authorship is expected to include participants from the member countries. We recommend that specific articles be outlined during the Crimea meeting in February, 1992.

7.3 Future HYDROBLACK Expeditions

The Hydroblack framework is an extremely useful one for basin-wide monitoring and observations. We recommend that these cruises continue on a twice-yearly basis, to provide complete seasonal data on the ocean physics, biology, geology, and chemistry. These quasi-synoptic measurements will be useful not only for basin-wide monitoring, but also for providing the framework for site-specific, process-oriented studies that will take place as part of the Cooperative Marine Science Program.

Future Hydroblack expeditions should be carried out with more complete intercalibration plans, particularly for the biological and chemical measurements. Future Hydroblack expeditions should learn from the deficiencies of HYDROBLACK '91. One goal of the February 1992 Crimea meeting should be to clarify improvements to the sampling and analysis protocol for the Hydroblack expeditions of the future.

For example, the present CTD intercalibration exercise demonstrated several deficiencies in the CTD analysis:

- The CTD's used should have accuracies on the order of that provided by the Sea Bird SBE 9. Since deep-water processes are of interest to the interdisciplinary study team, the CTD's must be accurate to full water depths of 2200 m.

- More effort should be placed on having ships take synoptic intercalibration samples in the Black Sea during the cruise. Variability in upper waters during intervals of weeks complicates the intercalibration exercise.

- Vertical bottle samples should be taken at several intercalibration stations, including bottles taken at approximately 5 depths throughout the water column. This exercise will help calibrate the individual CTD's throughout the cruise, to evaluate for drift and calibration offsets. The bottles used must be glass, and must follow a specific protocol to assure good salinities can be derived from high quality salinometers.

- Sampling density (rate, lowering speed, etc.) must be carefully adhered to, to prevent spiking near the intense chemocline. Similarly, water column sampling for chemistry and biology should be aware of the filtering effects of a heaving ship with a sampler hanging in a sharp chemocline.

Similar improvements should be derived for the other biological and chemical sampling and analysis protocols, and implemented during future Hydroblack expeditions.

Finally, additional measurements should be incorporated into future Hydroblack expeditions. For instance:

- Current meters would be useful for linkage with the dynamic height calculations, particularly for use with diagnostic numerical circulation models.

- Tracer studies, focusing on cesium and other Chernobyl products, should be incorporated to improve our understanding of mixing processes on longer time scales.

- Numerical model simulations should be incorporated to provide a feedback between model development and field data.

8. REFERENCES

Fofonoff, N.P. and R.C. Millard, 1983. Algorithms for Computation of Fundamental Properties of Seawater. Unesco Technical Papers in Marine Science NO. 44, 53 pp.

Oppenheim, A.V. and R.W. Schafer, 1975. Digital Signal Processing. Prentice-Hall, Englewood Cliffs, New Jersey, 585 pp.

ANNEX I

WORKSHOP AGENDA

HYDROBLACK 1991

INTERCALIBRATION MEETING

1-10 DECEMBER 1991

SCHEDULE

30 Nov - 1 Dec.: Arrival of participants to Woods Hole

Monday, 2 Dec. 0800 Arrival in Clark 257

Agenda: Discuss goals of intercalibration exercise.
Agree on strategies for intercalibration exercise
Show preliminary results of some intercalibration procedures
Discuss programming languages, plotting packages, etc.
View intercalibration issues on computer screen: evaluate techniques for filtering, wild-point editors, etc.
Discuss bottle samples versus ship intercalibration procedures
Enter *Parshin* data to SUN workstation
Evening: Free. Shopping as required.

Tuesday, 3 Dec. 0800 Arrival in Clark 257

Agenda: Complete programming for filtering, spike-removal, and determine intercalibration constants.
Apply intercalibration to all stations

1800: Dinner at Aubrey's

Wednesday, 4 Dec. 0800: Arrival in Clark 257

Agenda: Complete intercalibration for all stations.
Prepare horizontal and vertical sections of hydrographic parameters, to evaluate the success of the intercalibration. Examine and correct for poor intercalibration
Add available chemical and biological data to data base. Examine the interrelationships between these data.

Evening: Free. Shopping in Town, touring, etc.

Thursday, 5 Dec. 0800: Arrival at Clark 257

Agenda: Calculate dynamic heights for all intercalibrated stations. Reference to 1000 m depth.
Plot hydrophysical fields, including T-S diagrams, sections, etc. Discuss deep sea and shelf circulation patterns, water masses.
Begin final plots and writing for technical report: Intercalibration study.

Evening: free.

Friday, 6 December 0800: Arrival at Clark 257

Agenda: Complete technical report draft.

Evening: Cocktail party at Aubrey's.

Saturday, 7 December 0800: Arrival at Clark 257 (Pick-up: no shuttle service)

Agenda: Outline paper(s) on HYDROBLACK 1991: discuss science issues. For example, discuss articles on water masses, general circulation, relationships to oxygen/chemoclines, shelf mixing processes, etc.

Evening: Free

Sunday, 8 December Possible tour of Cape Cod or trip to Boston.

Monday, 9 December 0800: Arrival at Clark 257

Agenda: Discuss science issues.

Evening: Free

Tuesday, 10 December 0800: Arrival at Clark 257

Agenda: Review Technical Report on Intercalibration exercise. Finalize report.

Wednesday, 11 December Depart Woods Hole

ANNEX II

HYDROBLACK 1991

INTERNATIONAL RESEARCH CRUISE ON HYDROGRAPHY OF THE BLACK SEA

CRUISE PLAN JULY 1991

1. SCIENTIFIC OBJECTIVES OF HYDROBLACK 1991

The existing scientific studies on the Black Sea oceanography indicate that the major physical, chemical and biological processes are poorly understood and further studies are essential. There is growing recent evidence that the environmental conditions of the sea are changing. It is timely to carry out multi-institutional interdisciplinary studies on the oceanography of the Black Sea because the problems to be addressed have regional importance, their solutions are of practical consequence, and they require coordinated research efforts between neighboring countries.

Dynamical characteristics of the Black Sea are influenced by winds and density differences due to heating/cooling, evaporation, precipitation, inflow/outflow from straits and the river run-off. All these sources act on the Black Sea and contribute to its temporally and spatially complex pattern of circulation. the circulation consists of a permanent cyclonic rim current complicated by a field of eddies, intense jets, filaments and meandering currents along the coasts. The circulation seems to have both transient and stationary components: at times the mesoscale variability appears to mask the general circulation.

In the Black Sea, the so-called Cold Intermediate Water mass is formed in the northwestern shelf region as well as in the upwelled waters of the basin's interior. Neither the process of formation (e.g., intensity and patchiness of convection events) nor the subsequent spreading, mixing and transformation characteristics of this water mass are clearly understood and deserve further scientific studies.

The overall scientific objective for the Black Sea oceanographic studies is to establish a definitive phenomenology to understand and quantify the roles of the fundamental physical processes and their impact on the biology and chemistry of the Black Sea. The results will form a better understanding of the transport and dispersion of material, the biological productivity of the basin, the efficient utilization of marine resources and environmental management including the control of pollution. The following are some specific problems at need to be addressed to achieve this objective:

1.1 intercomparison of the main forcing mechanisms; the wind versus thermohaline forcing, source/sink flow through straits as reflected in the spatial as well as seasonal and interannual variability and budgets,

1.2 the role played by the topography and the irregular coastline,

1.3 characteristics of the convection processes associated with the Cold Intermediate Water formation and its subsequent sinking, spreading and mixing,

1.4 identification of the major features of circulation, its variability, energetics and basic space and time scales,

1.5 analysis of available historical data sets and satellite imagery (both AVHRR and CZCS),

1.6 determination of the dissolved oxygen and hydrogen sulfide concentrations and the features of the oxic/anoxic interface,

1.7 the influence and implications of the circulation on the distribution of biological and chemical properties,

1.8 determination of important sources and sinks of nutrients and the role of eddies in the nutrient transport and primary productivity,

1.9 determination of horizontal and vertical material fluxes within the sea and their variability,

1.10 investigation of the primary biogeochemical processes of the euphotic and aphotic zones of the water column,

1.11 impact of eddies and other features of circulations on fisheries through recruitment and/or production.

The program will contain not only hydrographic and biochemical measurements, but also remotely sensed data to aid in the interpretation of the hydrophysical measurements as well as numerical modeling studies to motivate a better understanding of the dynamical background of the physical processes.

2. ELEMENTS OF THE HYDROBLACK 1991 RESEARCH PROGRAM

In order to achieve some of the scientific objectives specified in the previous section, a basin-wide multi-institutional survey is planned during September 1991. The survey is aimed to quantify the spatial distribution of important physical and biochemical parameters and their interrelations with the mesoscale features (eddies, jets and filaments, etc.). The objectives listed above can be accomplished by the determination and/or measurement of the following parameters:

2.1 Meteorological Measurements. The following meteorological parameters will be measured aboard each ship:

2.1.1 Time (GMT; Greenwich Mean Time)
2.1.2 Location (latitude/longitude, using GPS if possible)
2.1.3 Air temperature (degrees Celsius)
2.1.4 Humidity (Relative humidity, dew point or wet bulb)
2.1.5 Wind speed and direction (m/sec, degrees from north)
2.1.6 Atmospheric pressure (millibars)
2.1.7 Sea surface temperature (degrees Celsius)

These measurements will be made every three hours starting from 00.00 GMT. Parameters 3 through 5 should be measured as closely as possible to the 10 m height as required by bulk flux formulae. Additional measurements could be helpful but are not required.

2.2 Physical Measurements. The station network for the HydroBlack 1991 September survey is shown in Figure 1. The CTD stations (Figure 1) are located on a grid with spacing of 1/3° latitude (20 miles) and 1/2° longitude (about 22 miles). CTD measurements (depth versus temperature and conductivity) will be obtained up to a nominal depth of 1000 m excluding the predetermined intercalibration stations and one out of every third deep station, where the measurements will extend to the bottom (about 2000 m). CTD system should be lowered at a rate of about 0.5 m/sec and data should be collected during downcast.

The raw CTD data obtained for all stations shall be processed by each party in the form of pressure, temperature, salinity, sigma-t. The processed data must be in bin-averaged form at 1 db pressure intervals.

2.3 Biochemical Measurements. The biochemical parameters (Table 1) will be measured at the stations shown in Figure 1. Dissolved oxygen, hydrogen sulfide, phosphate, nitrate and chlorophyll-a are the main parameters to be measured in the HydroBlack 1991 program. The other parameters listed in Table 1 are optional.

Biochemical measurements are carried out at smaller number of stations along selected transects. These transects will be chosen before the cruise in the regions where important physical variability is anticipated. The water samples should be taken with the Rosette samplers at prespecified depth levels depending on the biological and chemical quantities desired. The standard depth levels specified for this study are 5 m, 20 m, 50 m, 75 m, 100 m, 125 m, 150 m, 200 m, 250 m, 300 m, 400 m, 500 m, 750 m, 1000 m, 1250 m, 1500 m, 1800 m and 2000 m.

Secchi disk depths will be measured at all the CTD stations.

2.4 Intercalibration Requirements. Intercalibration constitutes an essential component of the HydroBlack 1991 program. All measurements should be carried out with calibrated instruments. Meteorological instruments should be calibrated with the local meteorological service before the cruise. CTD sensors should be calibrated before the cruise by the manufacturer.

Intercalibration stations are selected for the comparison and intercalibration of the different sets of instruments used in each joint research area. These stations should ideally be occupied simultaneously by the individual ships but a reasonable time lag between the measurements would have to be allowed. the uniform properties of the Benthic Boundary Layer (about 400 m deep) near the bottom forms an ideal environment for the intercalibration of the physical measurements.

Integration of the CTD observations from different profilers requires an estimate of the error associated with each CTD profiler. Salinity values will be calibrated against salinometer in Woods Hole Oceanographic Institution (WHOI). For this purpose, one 100 ml water sample will be taken during the upcast at a depth where temperature and salinity are vertically homogeneous. Salinity sample bottles will be provided by WHOI. The following information should be recorded at each station: Station name, Time & Date (GMT), CTD pressure, CTD temperature, CTD conductivity, CTD salinity (three decimal places), and the sample bottle number. After the cruise, the water samples and a copy of the station log will be sent to Dave Aubrey at WHOI where the bottle salinity will be measured with the high quality salinometer. The *in situ* true conductivity will then be calculated from the CTD pressure and temperature, and the bottle salinity. The difference between the *in situ* true conductivity and the CTD conductivity is the sensor error. Systematic errors can later be used to correct the raw conductivity.

For the intercalibration of nitrate, phosphate and chlorophyll-a, standard water samples will be provided by the Institute of Marine Sciences, Erdemli, Turkey. These samples will b distributed amongst parties prior to the cruise, if possible.

2.5 Remote Sensing. The HydroBlack 1991 program will also be supported by the remote sensing facilities of the participating institutions. Woods Hole Oceanographic Institution (USA), Marine Hydrophysical Institute, Ukrainian Academy of Sciences (USSR) and Institute of Marine Sciences, Middle East Technical University (TURKEY) will provide the AVHRR (infrared) imagery for the Black Sea. The imagery will include a sequence of pictures that will describe the temporal evolution of the features in the sea. A period of about one month starting from one week before the survey and ending a week after the end of the survey is accepted as the optimum period for the coverage of the AVHRR data.

The Institute of Marine Sciences, Middle East Technical University will attempt to provide the real time AVHRR infrared and visible satellite data through the Automatic Picture Transmission (APT) system in use at Erdemli campus (APT System gives three AVHRR pictures of the Black Sea per day with the 4 km x 4 km pixel resolution).

2.6 Data Exchange. The processed CTD data sets (i.e., one meter bin-averaged and converted to the form of pressure, temperature, salinity and density) will be exchanged between all participating groups in the form of ASCII files on IBM compatible 5.25 or 3.50 inches

flexible diskettes. The precise format of the CTD data is given in Table 2. The CTD data will be exchanged at Varna-BULGARIA during the Workshop on the Black Sea to be held at the end of September 1991.

A workshop is planned in November 1991 to pool all the CTD data, make a collective data set and carry out the cooperative and synthetic scientific analysis. For this purpose, the quality control of the CTD data sets will be first checked for instrument error. They will then be intercalibrated with respect to bottle-calibrated CTD measurements and by other means which will be set during the workshop. The final form of the pooled data set will contain pressure, potential temperature, salinity and sigma-theta.

The place and time f the November 1991 workshop will be decided by the Steering Committee of the Black Sea programme during the Varna meeting.

Because a major part of the biochemical samples requires laboratory analyses, exchange of the biochemical data will be done within three months following the completion of the cruise. It is also exchanged in the form of ASCII files on the IBM compatible 5.25 and 3.50 inches diskettes. Considering the difficulty in assigning a common format for the data exchange of biochemical parameters, the form of the data will be decided individually by each party. A brief description of the format should, however, be provided together with the diskettes.

For a period of three years after exchange, the data will be considered to be property of the party collecting the data, and can not be published by another party without permission of the responsible party. Joint publications are encouraged. After three years, the complete data set will be considered common property of the participating institutions.

2.7 Publications. On the basis of the data gathered during HydroBlack 1991 survey, a series of joint publications will be produced within the first three years. These joint publications will bear the name of scientists participating in the HydroBlack 1991 program. They will be prepared in English and submitted to peer-reviewed oceanographic journals. Additional articles may also be prepared in the native languages of each party.

Exchange of scientists between the participating groups is desirable for previewing and evaluation of the data and the preparation of joint articles. The time and place of these meetings will be decided by the organizing committee of the HydroBlack 1991 program and is subject to the availability of funds.

3. DETAILED CRUISE PROGRAM

The station network presented in Figure 1 is covered by six ships. the name of the ships, cruise coordinators and the chief scientists assigned for each ship are given in Table 3. the equipment available on board for each ship are listed in Table 4. The cruise schedule for the ships is planned such that a quasi-synoptic results are achieved. the survey period will start within the first week of September, 1991 and is expected to continue not more than two weeks. Approximate dates of starting the survey for each ship are given in Table 5. The locations of stations which will be visited by each party are listed in Table 6.

Each ship will cover a certain region (Figures 1) but there are some overlapping stations which will be visited by more than one ship during the survey. These common stations are essential for intercalibration purposes.

Areas of responsibility assigned for each ship are shown in Figures 1. Figure 1 shows a total of 138 CTD stations to be visited by the Soviet ships. The R/V *Vodyanitsky* will cover 72 CTD stations situated within the northeastern part, the R/V *Kolesnikov* will cover 36 CTD stations in the central part of the Black Sea and the R/V *Gakkel* is planned to work at 40 stations situated in the northwestern shelf area.

The R/V *Vodyanitsky* and the R/V *Kolesnikov* will visit 5 common stations located along 34°45' longitude. Similarly, the R/V *Kolesnikov* and the R/V *Gakkel* will have 2 common stations

located along the continental slope of the northwestern Black Sea. The R/V *Vodyanitsky* and the R/V *Kolesnikov* will also have three intercalibration stations with the Turkish ships the R/V *Bilim* and the R/V *Piri Reis*.

Figure 1: There are 36 biochemical stations for R/V *Vodyanitsky,* 20 for R/V *Kolesnikov* and 18 for R/V *Gakkel*. Some of these stations are the common stations for the intercalibration/intercomparison purposes.

Figure 1 displays CTD stations (a total of 126) which will be visited by the Turkish ships. The R/V *Bilim* will cover 76 stations within the eastern and central parts of the study area. The R/V *Piri Reis* will work on the western part (60 stations). The R/V *Bilim* has two intercalibration stations with the R/V *Vodyanitsky,* and two with the R/V *Kolesnikov*. The R/V *Bilim* and the R/V *Piri Reis* will have 10 common stations. There are 33 stations for the R/V *Bilim* and 27 stations for the R/V *Piri Reis*. The common stations are also indicated.

Figure 1 shows the CTD stations (a total of 57) which will be covered by the R/V *Akademik*. As indicated above, there are some stations which will also be visited by other ships (e.g., R/V *Piri Reis,* R/V *Kolesnikov,* R/V *Gakkel*). 32 biochemical stations will be studied by the R/V *Akademik*.

R/V *Bilim* and R/V *Akademik* have been assigned as the mother ships responsible for ship to ship communications during the survey. R/V *Bilim* will be responsible for the communications on the daily operations of the R/V *Vodyanitsky* and R/V *Kolesnikov*. R/V *Akademik* will carry out the same task with the R/V *Gakkel* and R/V *Piri Reis*. A single side band will be assigned for this purpose. Ship to ship communications will be done twice a day at 0600 and 1400 GMT hours.

Starting date of the ships to the survey must be informed to other institutions. Institutions will be responsible to inform the others of the stations occupied by their ships every three days.

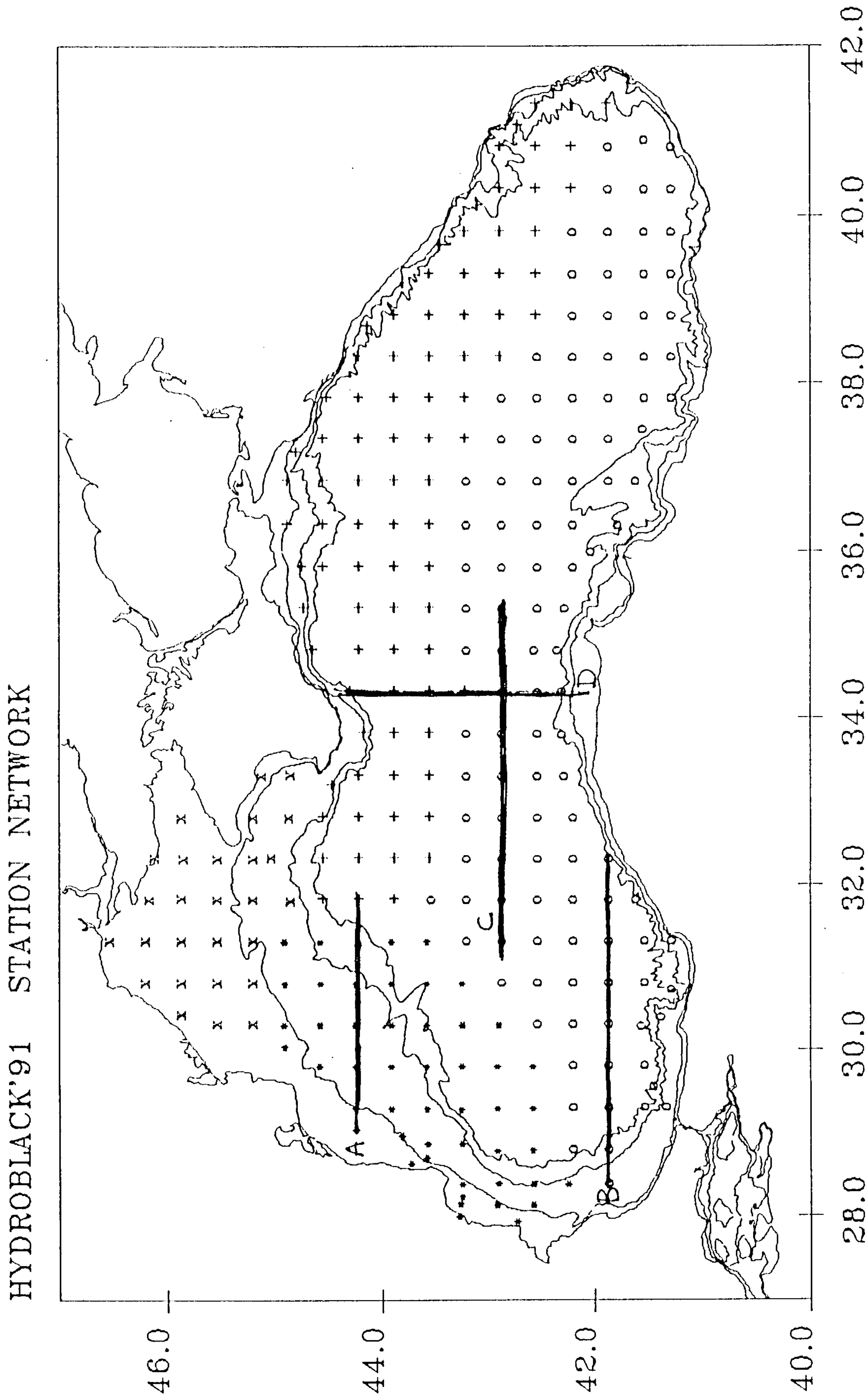


Figure 1. Station locations for HydroBlack '91. Circles are Turkish stations, asterisks are Romanian and Bulgarian stations, crosses and x's are Ukrainian and Russian stations.

Table 1

LIST OF BIOCHEMICAL PARAMETERS

Parameters	Stations	Amount sample required	Depth levels	Method & instrument	Notes
Dissolved Oxygen (O_2)	every 3rd st.	30 mL	12 (0-200 m)	winkler	(1)
Hyd. sulphide (H_2S)	every 3rd st.	300 mL	11 (75-1000 m)	Titration	(2)
Nutrients (NO_3, -PO_4)	selected Transects	1 L	14 (0-1000 m)	autoanalyzer	(3)
Chlorophyll-a (a) *in situ* (b) water sampling	every 3rd st.	 3 L	(0-100 m) continuous 5 levels	 fluorometer spectrophotometer	(5)
Optional Parameters					
Diss. Org. Carbon (DOC)	selected stations	100 mL	14 (0-1000 m)	autoanalyzer	(3)
Part. Org. Carbon (POC)	selected stations	10 L	4 (0-500 m)	CHN analyzer	(4)
Part. Org. Carbon (POC)	selected stations	10 L	4 (0-500 m)	CHN analyzer	(4)
Total Suspended Sediment (TSS)	selected stations	1 L	surface	gravimetry	
Eh & pH	selected stations	300 mL	9 (0-1000 m)	pH-meter	(6)
phytoplankton	selected stations	1L	surface	microscope	
zooplankton	selected stations	1 L	surface	microscope	
Heavy metals	selected stations		1 L	surface	atomic absorption

(1) 12 depth levels; 7 of these correspond to the standard depth levels (0 m, 20 m, 50 m, 75 m, 100 m, 150 m, 200 m). The rest will be finer resolution near the oxic/anoxic interface which is predetermined and/or guessed by other means (e.g., by direct oxygen measurements with CTD probe). The depth of 8°C isotherm below the Cold Intermediate Layer might be a reasonable depth level for starting the fine sampling.

(2) At the same stations with the dissolved oxygen and at 11 standard depth levels between 75 m and 100 m (75 m, 100 m, 125 m, 150 m, 200 m, 250 m, 300 m, 400 m, 500 m, 750 m, 1000 m). Additional water samples are taken near the oxic/anoxic interface with finer resolution.

(3) At 14 standard depth levels between 0 m and 1000 m (0 m, 20 m, 50 m, 75 m, 100 m, 125 m, 200 m, 250 m, 300 m, 400 m, 500 m, 750 m, 1000 m).

(4) At 4 depth levels (20 m, 100 m, 200 m, 500 m).

(5) At standard depth levels between 0 m and 100 m (0 m, 20 m, 50 m, 75 m, 100 m). In the discrete water sampling, standard spectrophotometric method will be employed by using GFC or GFF Whatman glass fiber filters.

(6) At 10 depth levels between 0 m and 1000 m (0 m, 20 m, 50 m, 100 m, 150 m, 200 m, 300 m, 500 m, 750 m, 1000 m).

Table 2

THE FORMAT OF A CTD DATA FILE

First line:	Latitude in Degrees, Minutes, and Seconds
Second line:	Longitude in Degrees, Minutes and Seconds
Third line:	Date and starting time for measurements; (in the form of MONTH DAY YEAR HOURS MINUTES) For example: 02 07 92 14 15
Fourth line:	The total depth at the station (in meters)
Fifth line:	The Secchi disk depth (in meters) (In the case of no Secchi disk depth data for the station, this line should be a blank line)
Sixth line:	Blank
Seventh line:	First line of the data set. Its form is: (PRES. (DB), TEMP. (Deg C), SAL. (ppt), SIGMA-T) Pressure (db), Temp (Deg. C), Sal. (psu), Density (cgs)
Eighth line:	Second line of the data set
:	:
:	:
:	:

The following format will be used for the data

First line:	FORMAT (3I2)
Second line:	FORMAT (3I2)
Third line:	FORMAT (5(I2, 2X))
Fourth line:	FORMAT (F5.0)
Fifth line:	FORMAT (F4.1)
Sixth line:	FORMAT (1X)
Seventh line:	FORMAT(I4, 3(1X, F7.4))
Eighth line:	"
:	"
:	"

In addition to the CTD data files for each station, there must be an ASCII file giving short descriptions for instruments, measurement techniques, the data processing procedure, etc.

Table 3

SHIPS, CRUISE COORDINATORS, AND CHIEF SCIENTISTS

Nationality	Ship	Chief Scientist	Cruise Coordinator
Bulgaria	R/V *Akademik*	A. Konsulov & D. Aubrey	Z. Belberov
Romania	None		V. Diaconu
Turkey	R/V *Bilim*	T. Oguz	Ü. Ünlüata
	R/V *Piri Reis*	T. Konuk	Ü. Ünlüata
U.S.A.	None		D. Aubrey
U.S.S.R.	R/V *Kolesnikov*	V. Latun	V. Latun
	R/V *Gakkel*	unknown	V. Latun
	R/V Vodyanitsky	unknown	V. Latun

Table 4

EQUIPMENT AVAILABLE ONBOARD SHIPS FOR HYDROBLACK 1991

Ship	CTD PROBE	Rosette Sampler	Winkler Tit. System	Auto-Analyzer	Fluoro-meter
R/V *Bilim*	SeaBird SBE-9	General Oceanics	semi-automatic (Hydro-bios)	Technicon multichan	Navitronic Q-200
R/V *Piri Reis*	SeaBird SBE-9	General Oceanics	semi-automatic (Brand)	Skalar multichan.	Spectro-photometer
R/V *Akademik*	Neil Brown	Not available	Conventional Lab Technique	Not available	Not available
R/V *Vodyanitsky*	SeaBird SBE-9	?	?	?	?
R/V *Kolesnikov*	ISTOK VII	?	?	?	?
R/V *Gakkel*	SBE-19 or SBE Sealogger	?	?	?	?

Table 5

STARTING DATES TO HYDROBLACK 1991 SURVEY FOR THE SHIPS

R/V *Bilim*	**September 1, 1991**
R/V *K. Piri Reis*	**September 5, 1991**
R/V *Akademik*	**September 3, 1991**
R/V *Kolesnikov*	**?**
R/V *Gakkel*	**?**
R/V *Vodyanitsky*	**?**

ANNEX III

CTD DESCRIPTIONS

HYDROPHYSICAL SOUNDING COMPLEX MHI 4102 (ISTOK)

TECHNICAL CHARACTERISTICS
The device has the following data channels:
- temperature data channel
- el.conductivity data channel
- hydrostatic pressure data channel
- channel of control code formation (pilot channel)

Channel	Range	Sensitivity	Accuracy	Output Code
Temperature	-2-(+35)°C	(0.0025°C (P=0.95))	±0.025°C	binary, 14 - digit
Conductivity (1st subrange) (2d subrange)	1.5-5.5 S/m 2.5-6.5 S/m	0.00025 S/m (P=0.95) ±(0.0002+3 x 10) S/m		binary, 14 - digit
Hydrostatic	0-60 MPa	0.025% x (Pmax) (P=0.95) ±0.5% x (Pmax)		binary, consecutive 13 - digit

Time of each parameter measurement is not more than 0.0625s. Discontinuity of each parameter measurement is not more then 0.25s. Heat inertia of the initial temperature-transformer-meter is not more than - 0.05s. Maximum lowering depth - 6000m

Dimensions of the device:
diameter - 600mm
height - 820mm
weight - 100kg

Input voltage 220 ± 20V , 50 ± 25Hz
Required power 70Watt
Communication is provided by the carrying single conductor cable (length 6,500m)
Environmental temperature - (-2°)-(+40)°C
Relative humidity - up to 80% at 27°C
16 sample bottles are attached to the device. Single bottle volume is 1 liter.

Data Recording

- binary and decimal code reflection on the informational panel;
- the information is carried to a personal computer.

Researcher : MHI, UkSSR Academy of Sciences, L.A.Koveshnikov.

The observations of the Secchi disk depth were performed with help of the standard white disk (0.3m diameter). Researcher : MHI, UkSSR Academy of Sciences, B.N.Krasheninnikov.

CTD UNDERWATER UNIT SeaBird SBE 9

TECHNICAL CHARACTERISTICS

The SBE 9 underwater units include temperature, conductivity and pressure sensors. Resultant data in Manchester Code is transmitted to the Deck unit. Twelve ASCII HEX characters representing six bites are transmitted per CTD scan.

The format for CTD scan is :
ttttccccpppp

tttt four HEX characters representing 2 bytes of temperature data
cccc four HEX characters representing 2 bites of conductivity data
pppp four HEX characters representing 2 bites of pressure data.

Sensor	Range	Resolution	Accuracy	Response Time
Temperature	-5 +35 deg C	0.0003 deg C	+/- 0.003 deg C	0.082 sec (0.5 m/sec drop) 0.070 sec (1.0 m/sec drop)
Conductivity	0-7 S/m	0.00004 S/m	+/- 0.0004 S/m	0.084 sec (0.5 m/sec drop) 0.070 sec (1.0 m/sec drop)
Depth	0-6000 m	0.004 %	+/- 0.02 %	0.001 sec

Weight: 24 kg in air, 15 kg in water

Size: 1.1 m x 0.2 m x 0.3 m

Communication is provided by single cable with length 7000m - *Akademik*, 1860 m - *Bilim* and 2200 m - *Piri Reis*.

CTD UNDERWATER UNIT SeaBird SBE 19

TECHNICAL CHARACTERISTICS

The SBE 19 underwater units include temperature, conductivity and pressure sensors. Data were stored in Random Access Memory, and uploaded to a microcomputer on board the ship.

Sensor	Range	Resolution	Accuracy	Response Time
Temperature	-5 +35 deg C	0.001 deg C	0.01 deg C/mo.	
Conductivity	0-7 S/m	0.0001 S/m	+/- 0.001 S/m/mo.	
Depth	0-2000 m	0.05 %	+/- 0.5 %	

HYDROPHYSICAL SOUNDING COMPLEX "HYDROZOND"

TECHNICAL CHARACTERISTICS
The device has the following data channels:
- temperature data channel
- el.conductivity data channel
- hydrostatic pressure data channel

Channel	Range	Sensitivity	Accuracy	Output Code
Temperature	-2-(+32)°C	0.01°C (P=0.95)	±0.03°C	binary, 12 digits
Conductivity (1st subrange) (2nd subrange)	0.5-3.5 S/m 3.5-6.5 S/m	0.001 S/m (P=0.95) ±(0.0035) S/m		binary, 12 digits
Hydrostatic	0-3.8 MPa 3.8-19.2MPa 19.2-60.0MPa	0.01MPa (±0.04MPa) 0.01MPa (±0.2MPa) 0.02MPa (±0.6MPa)		binary, consecutive 12 digits

Time of each parameter measurement is not more than 0.064s. Discontinuity of each parameter measurement is not more then 0.32s. Heat inertia of the initial temperature-transformer- meter is not more than - 0.5s. Maximum lowering depth - 6000m

Dimensions of the device:
diameter - 601mm
height - 736mm
weight - 63kg

Input voltage - 220 ± 20V , 50 ± 25Hz
Required power - 300Watt
Communication is provided by single conductor cable (length 4,000m)
Environmental temperature - (-2°)-(+40)°C
Relative humidity - up to 80% by 27°C
24 sample bottles are attached to the device. Single bottle volume is 1 liter

Data Recording

- binary and decimal code reflection on the informational panel;
- the information is carried to a personal computer.

Researcher : SOIN, UkSSR Academy of Sciences, L.V.Matsokin.

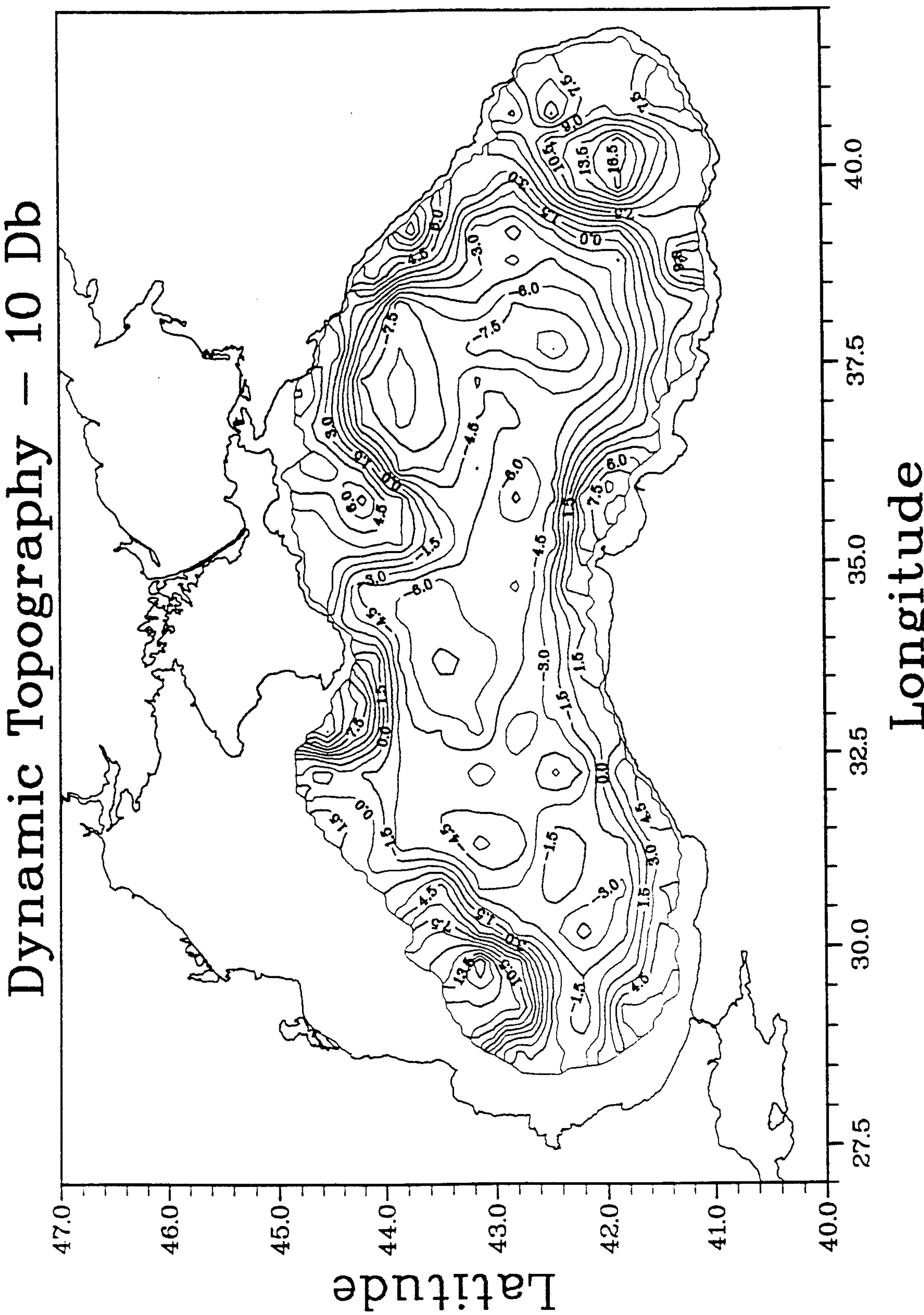
The observations of the Secchi disk depth were performed with help of the standard white disk (0.3m diameter).

Researcher : SOIN, UkSSR Academy of Sciences, V.V.Sidelnikov.

ANNEX IV

DYNAMIC HEIGHTS REFERENCED TO 900 db

Intercalibrated Results


Dynamic Topography — 10 Db
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Latitude
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30.0
32.5
35.0
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41.0
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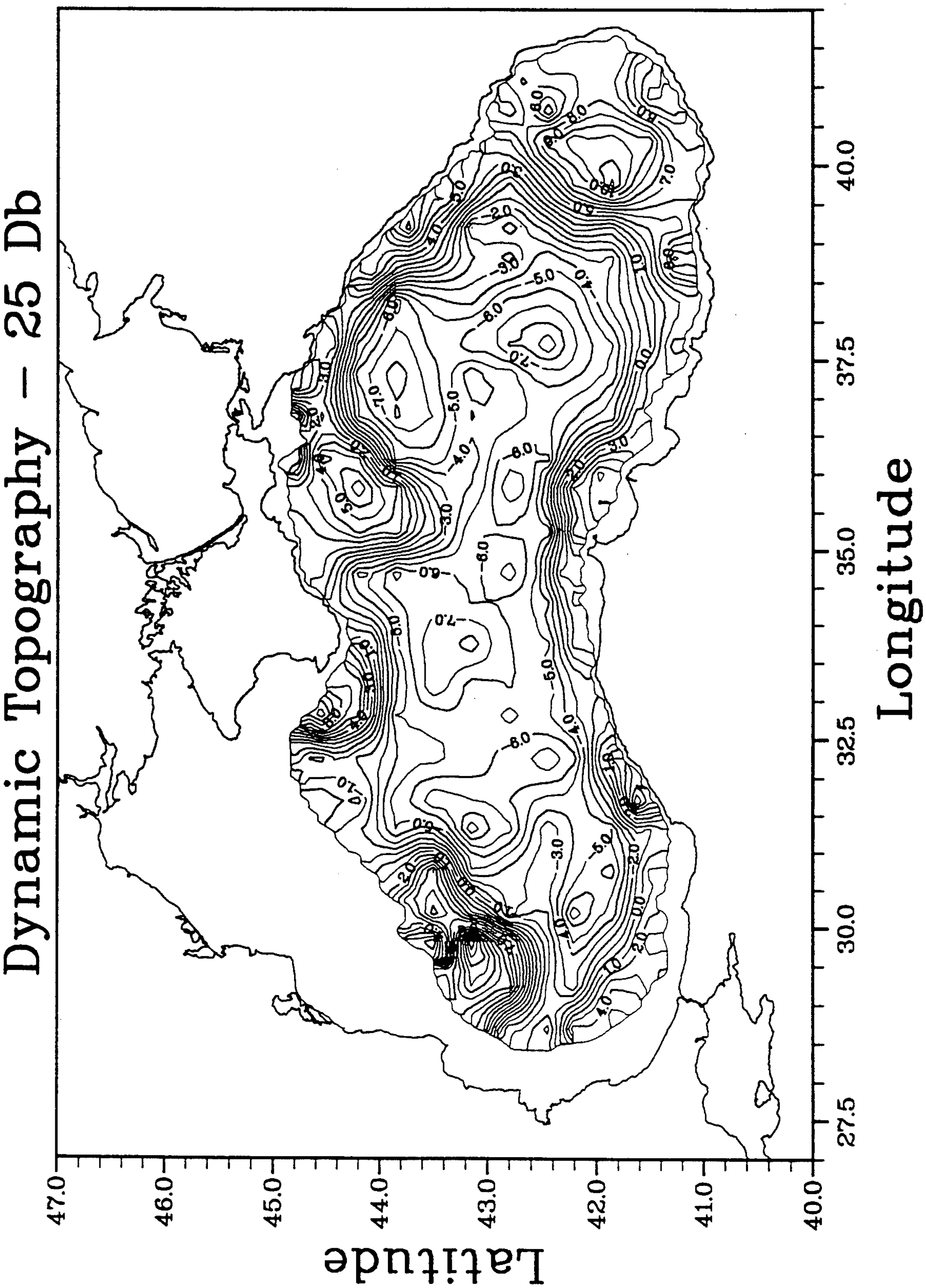
45.0
46.0
47.0


Dynamic Topography - 25 Db
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
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41.0
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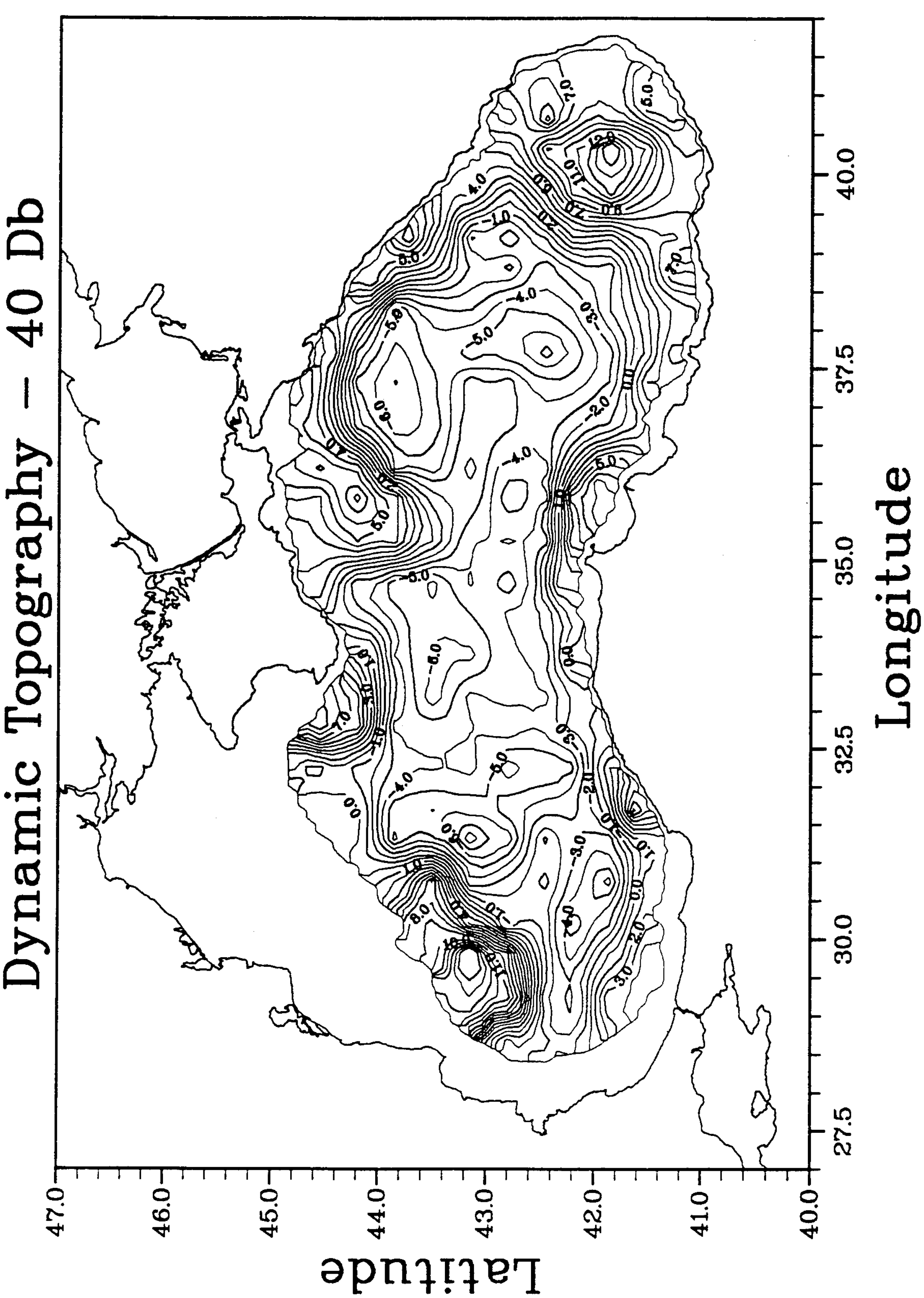
44.0
45.0
46.0
47.0


Dynamic Topography – 40 Db
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
40.0
41.0
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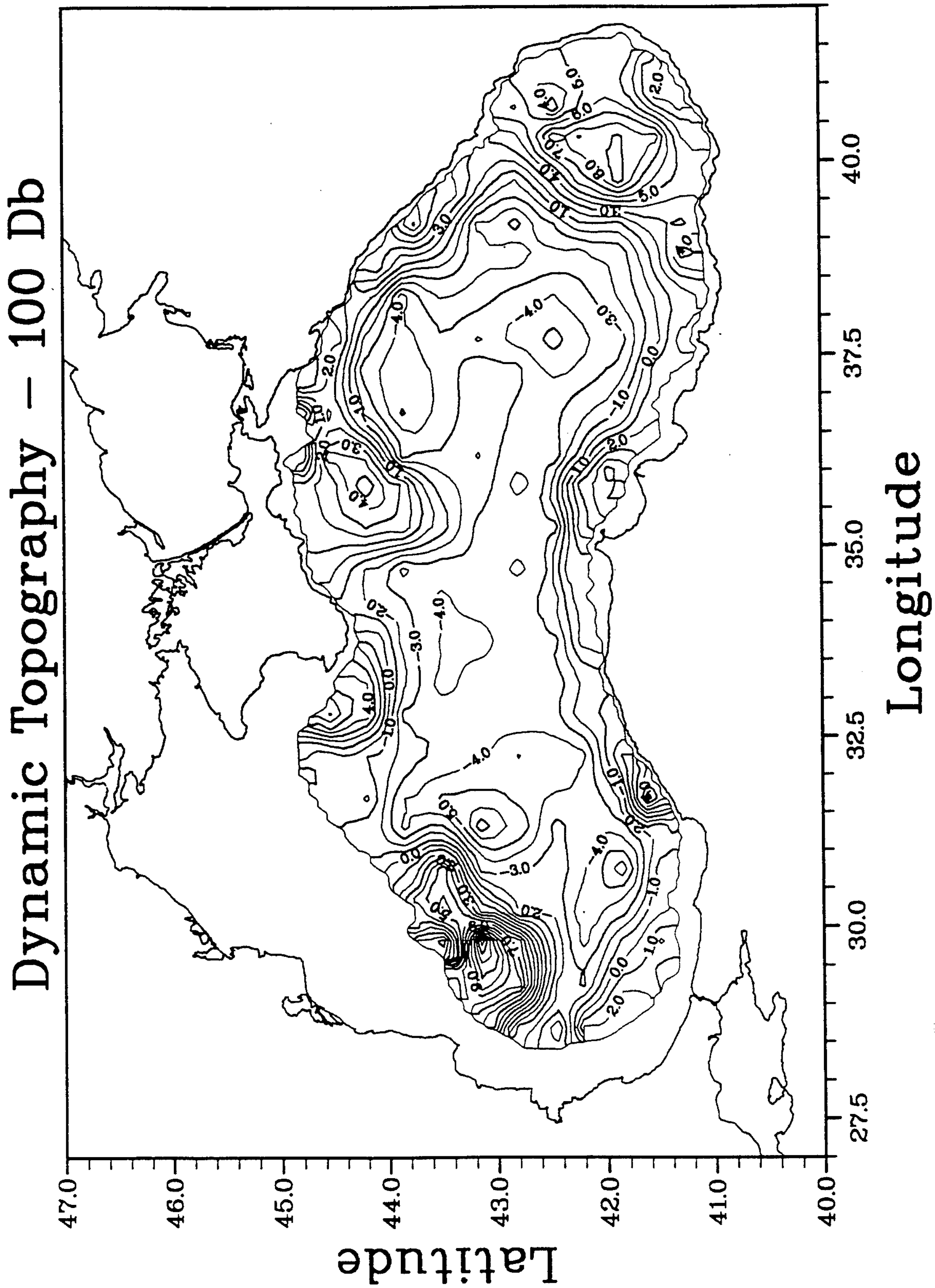
45.0
46.0
47.0


Dynamic Topography – 100 Db
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
40.0
41.0
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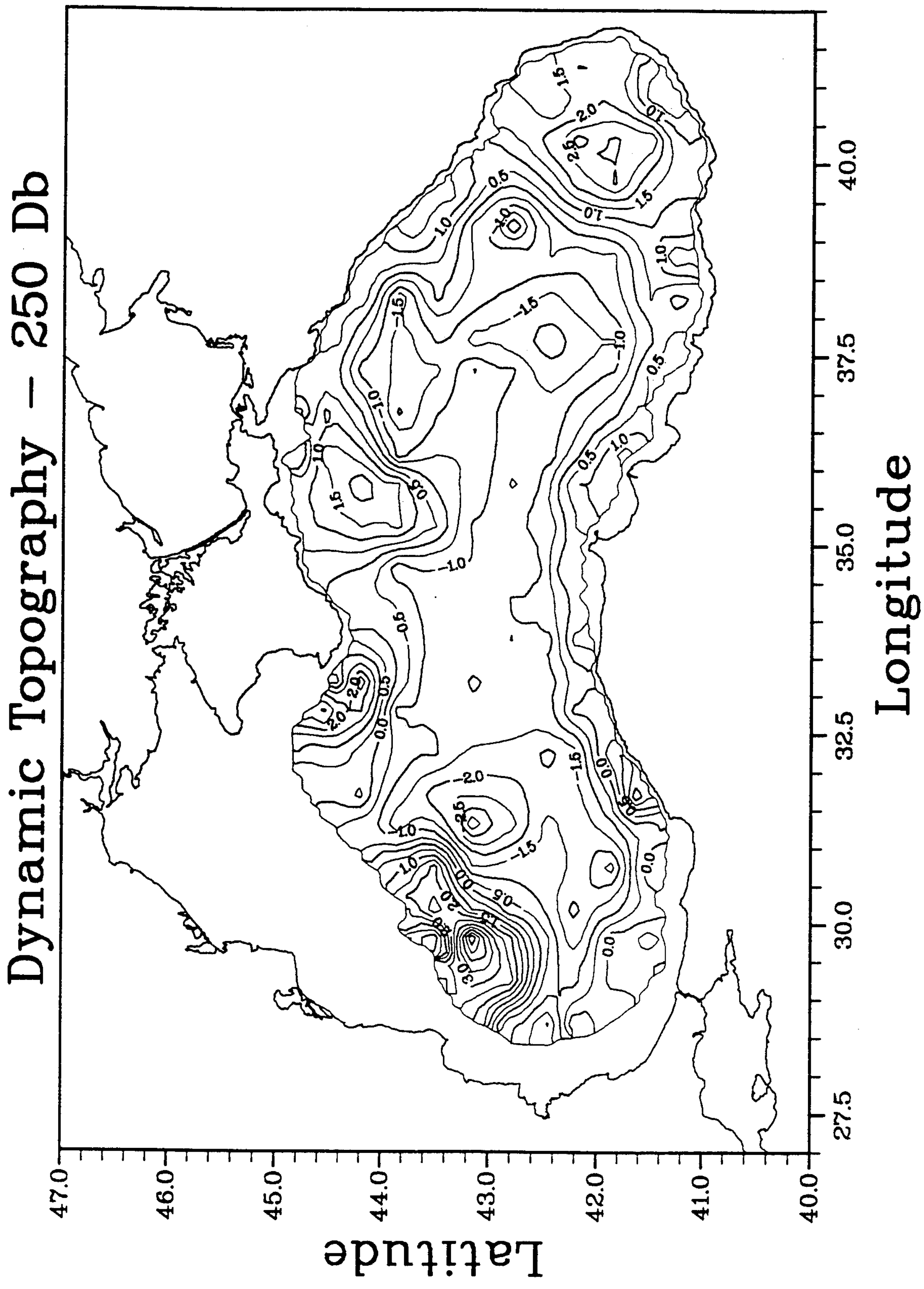
45.0
46.0
47.0


Dynamic Topography – 250 Db
Longitude
Latitude
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30.0
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37.5
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47.0
46.0
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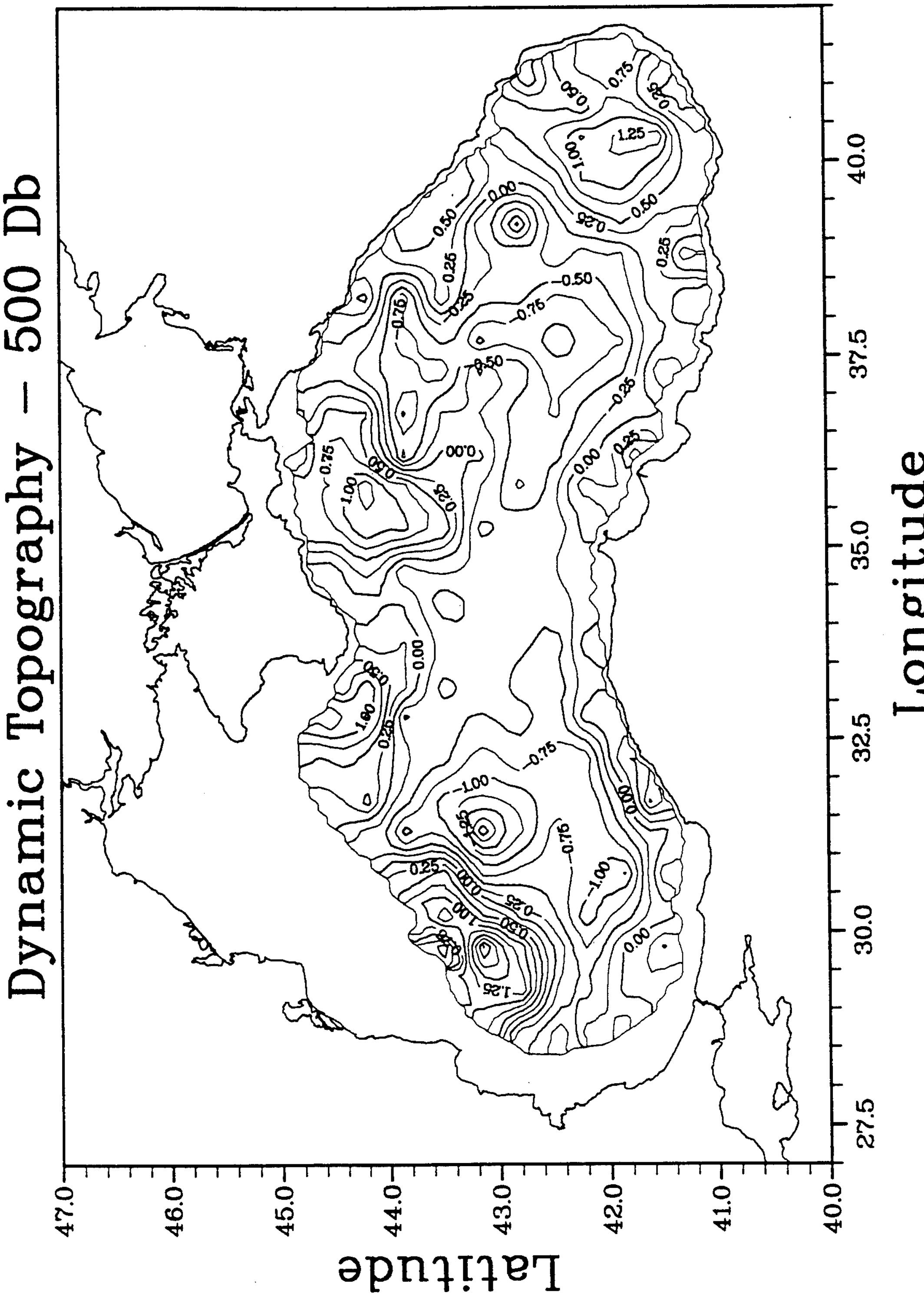
42.0
41.0
40.0


Dynamic Topography – 500 Db
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
47.0
46.0
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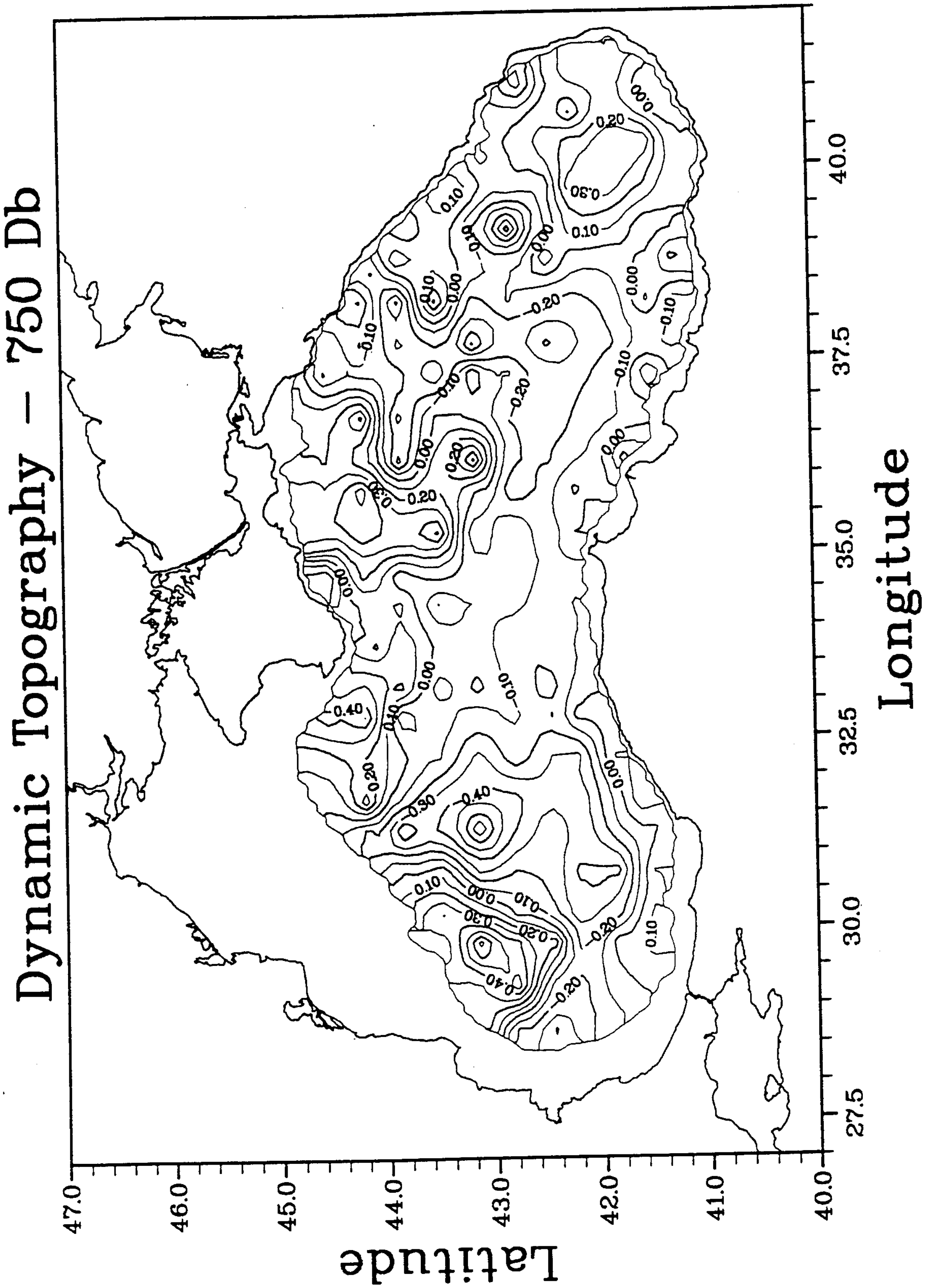
42.0
41.0
40.0


Dynamic Topography – 750 Db
Longitude
Latitude
27.5
30.0
32.5
35.0
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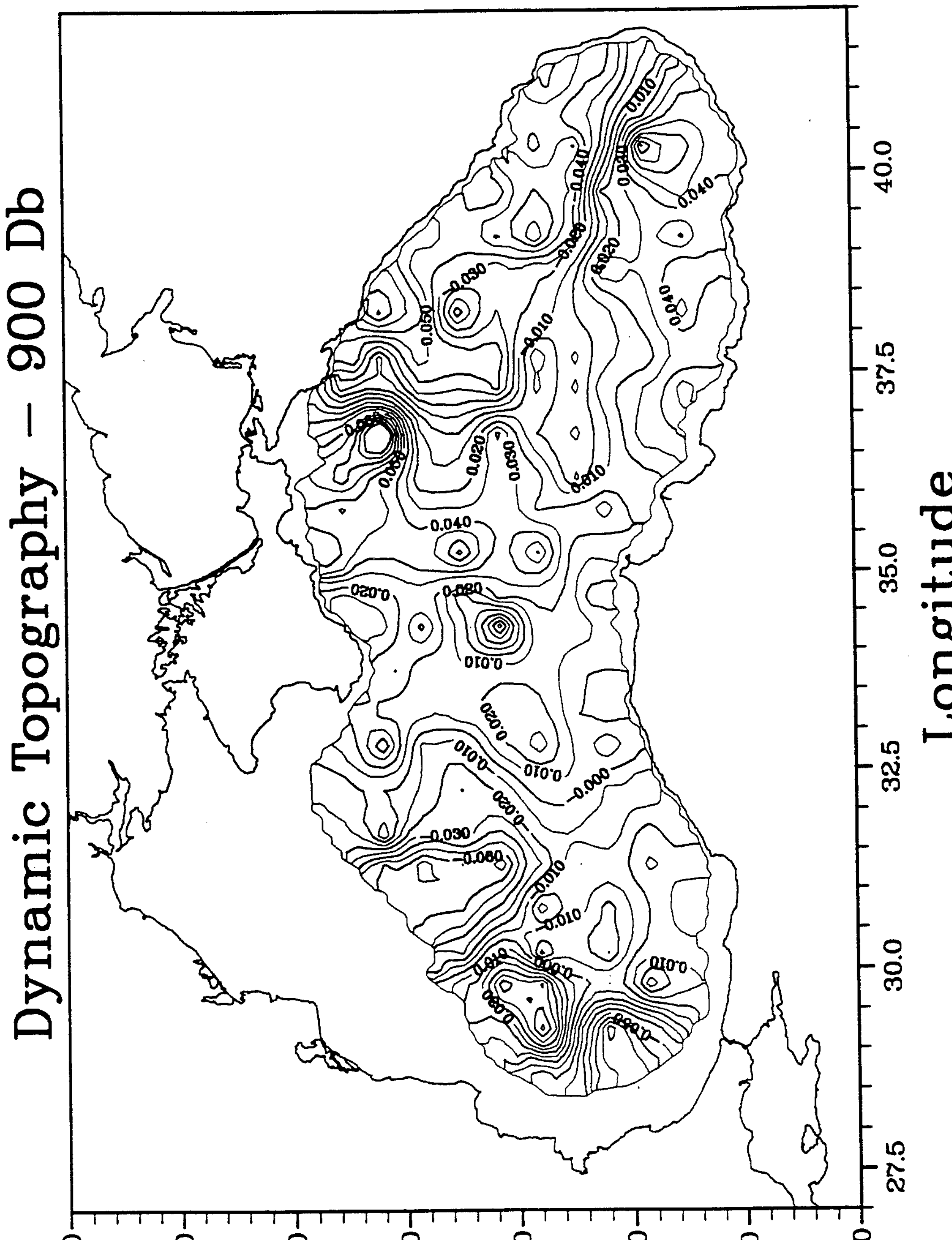
45.0
46.0
47.0


Dynamic Topography – 900 Db
Longitude
Latitude
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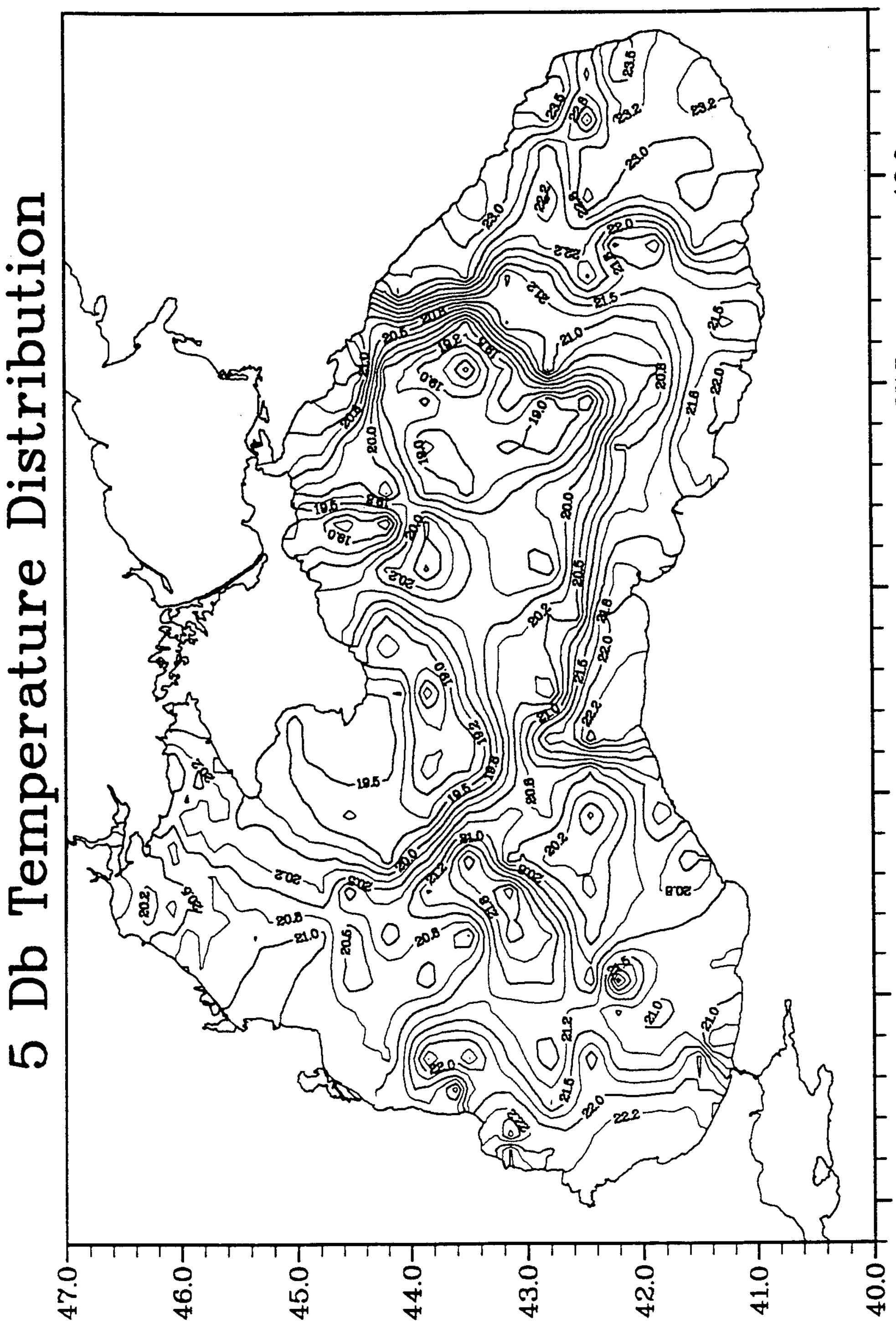
30.0
32.5
35.0
37.5
40.0
40.0
41.0
42.0
43.0
44.0
45.0
46.0
47.0

ANNEX V

SAMPLE SECTIONS OF SALINITY, TEMPERATURE, AND DENSITY

Intercalibrated Results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Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
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40.0
41.0
42.0
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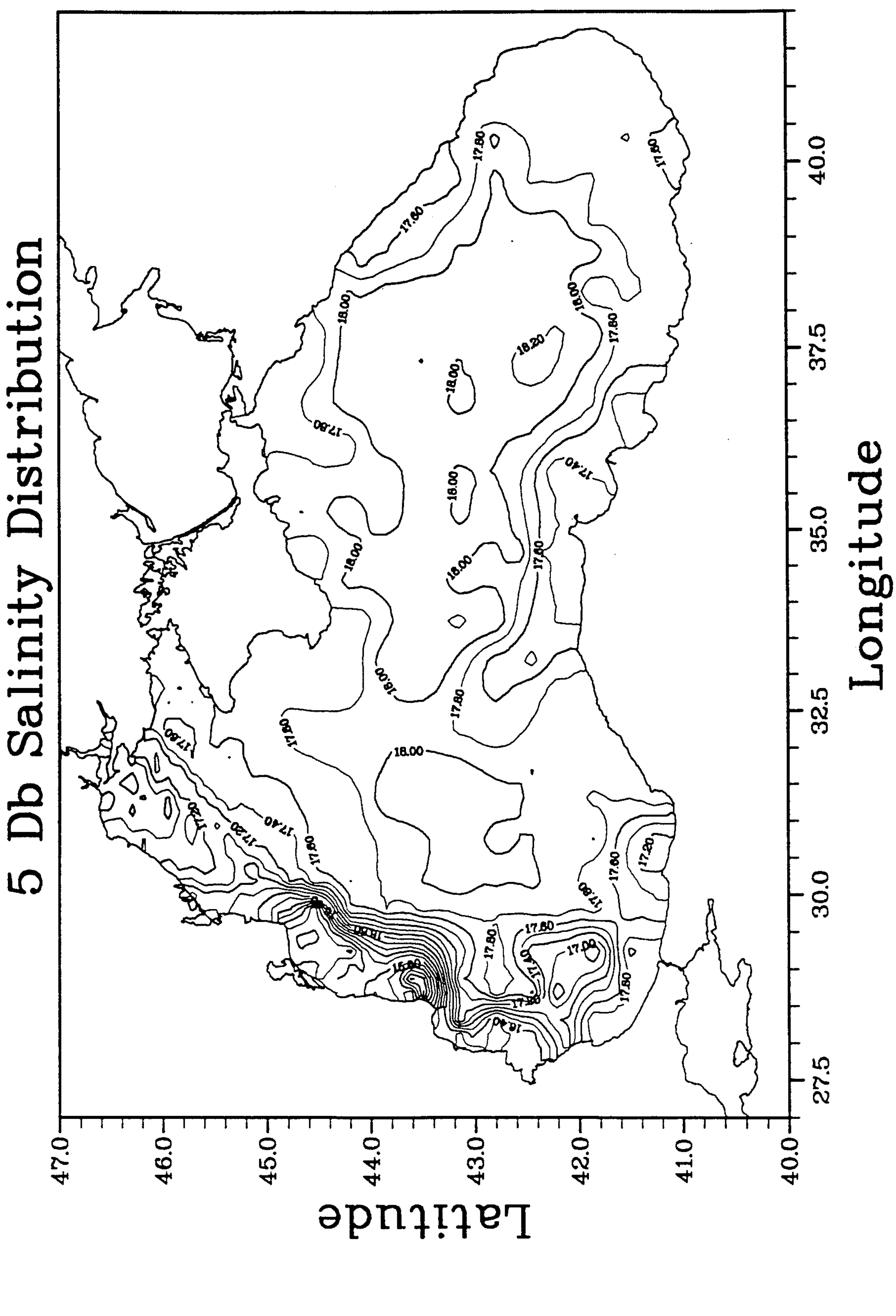
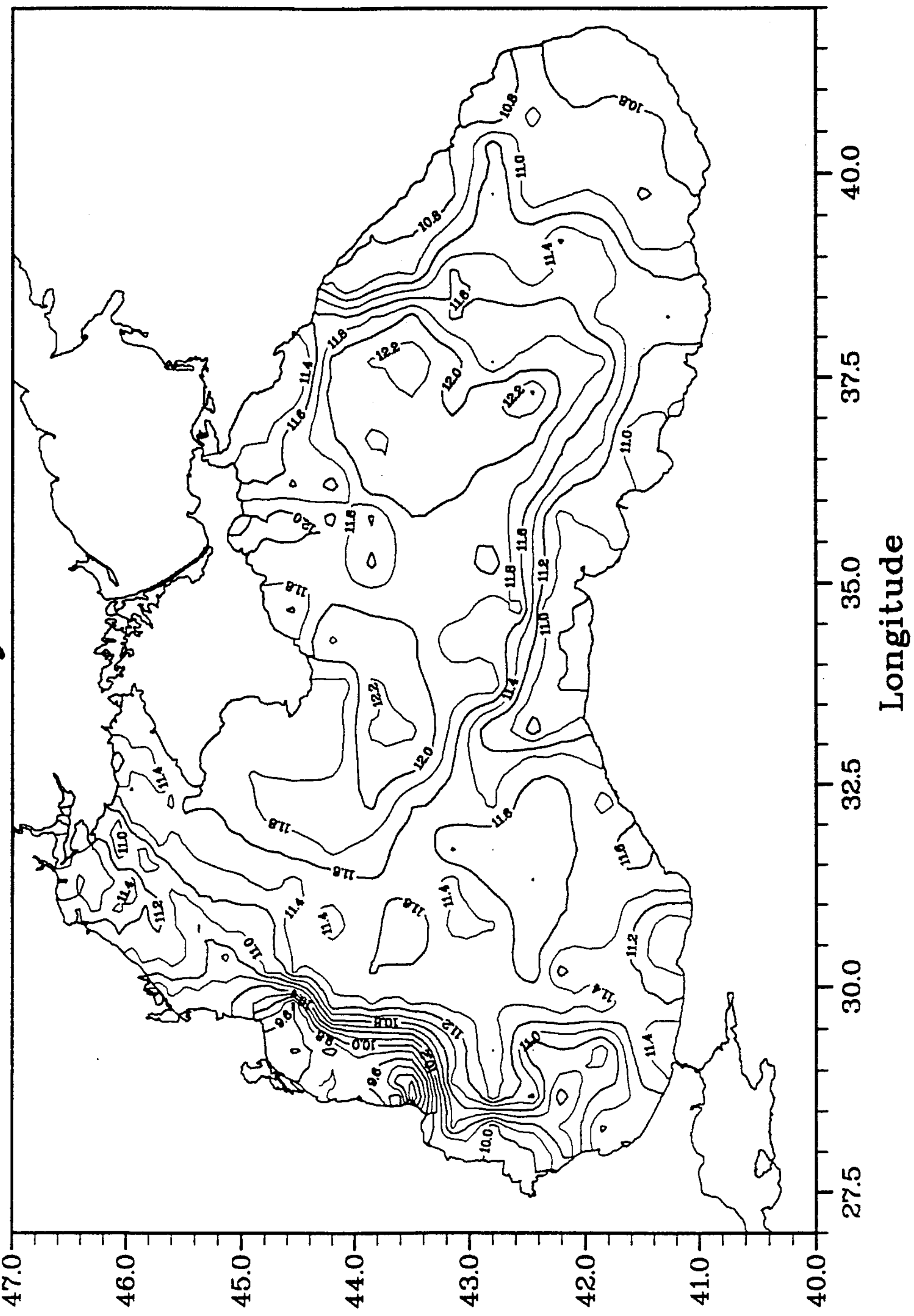
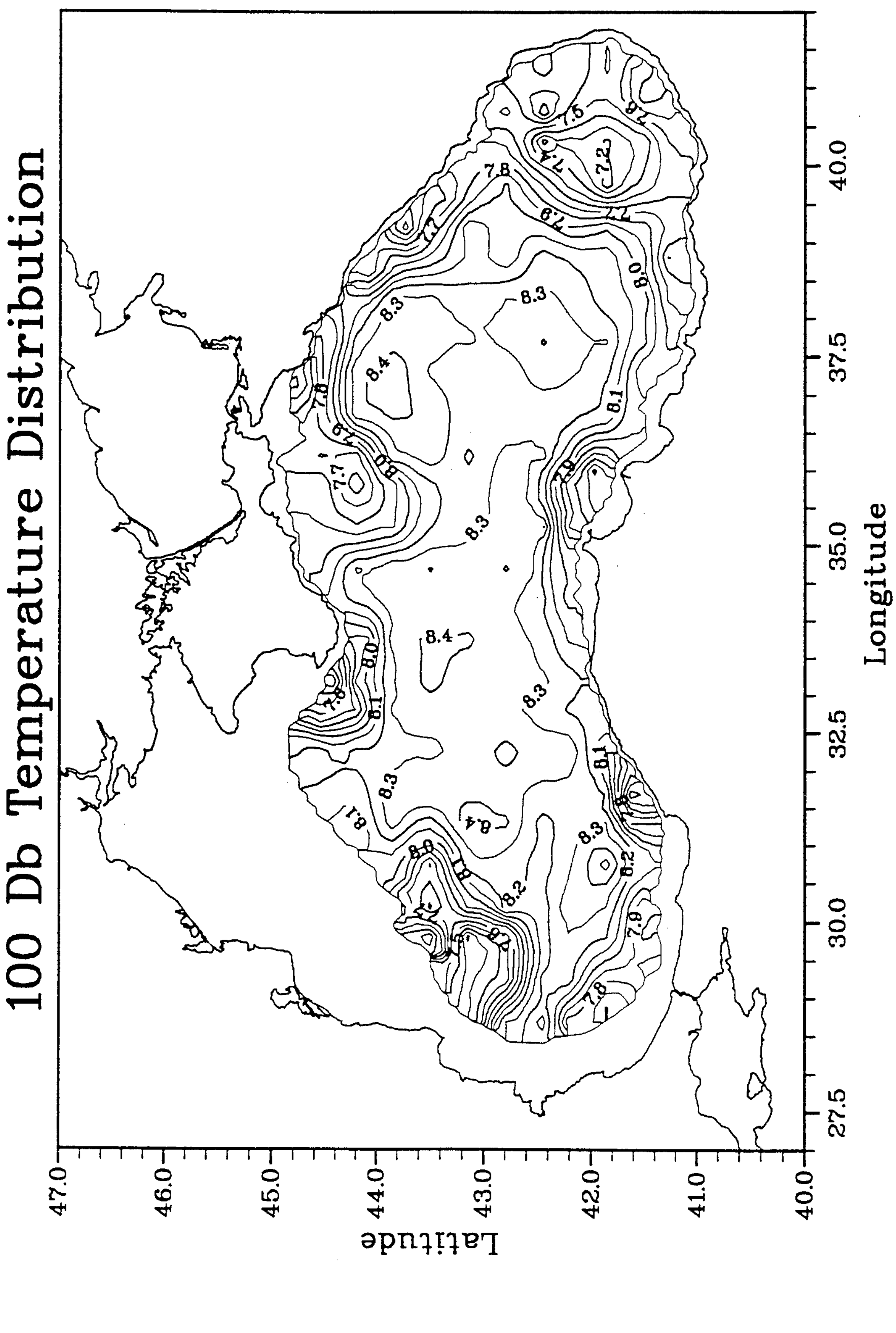
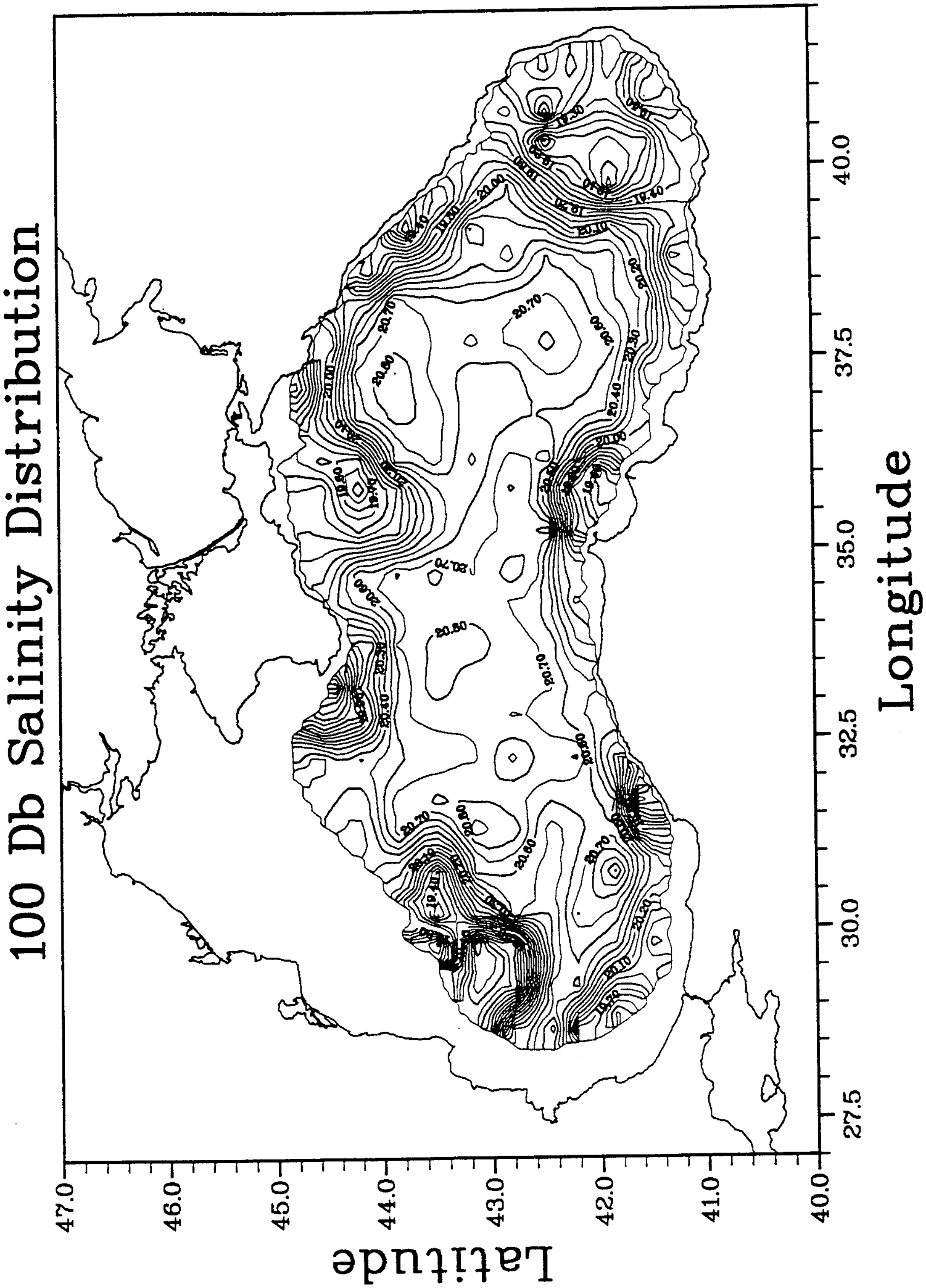
45.0
46.0
47.0


5 Db Salinity Distribution
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
18.00
18.20
17.80
17.60
17.40
17.20
17.00

5 Db Density Distribution




100 Db Temperature Distribution
Latitude
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
Longitude
27.5
30.0
32.5
35.0
37.5
40.0


100 Db Salinity Distribution
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
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46.0
45.0
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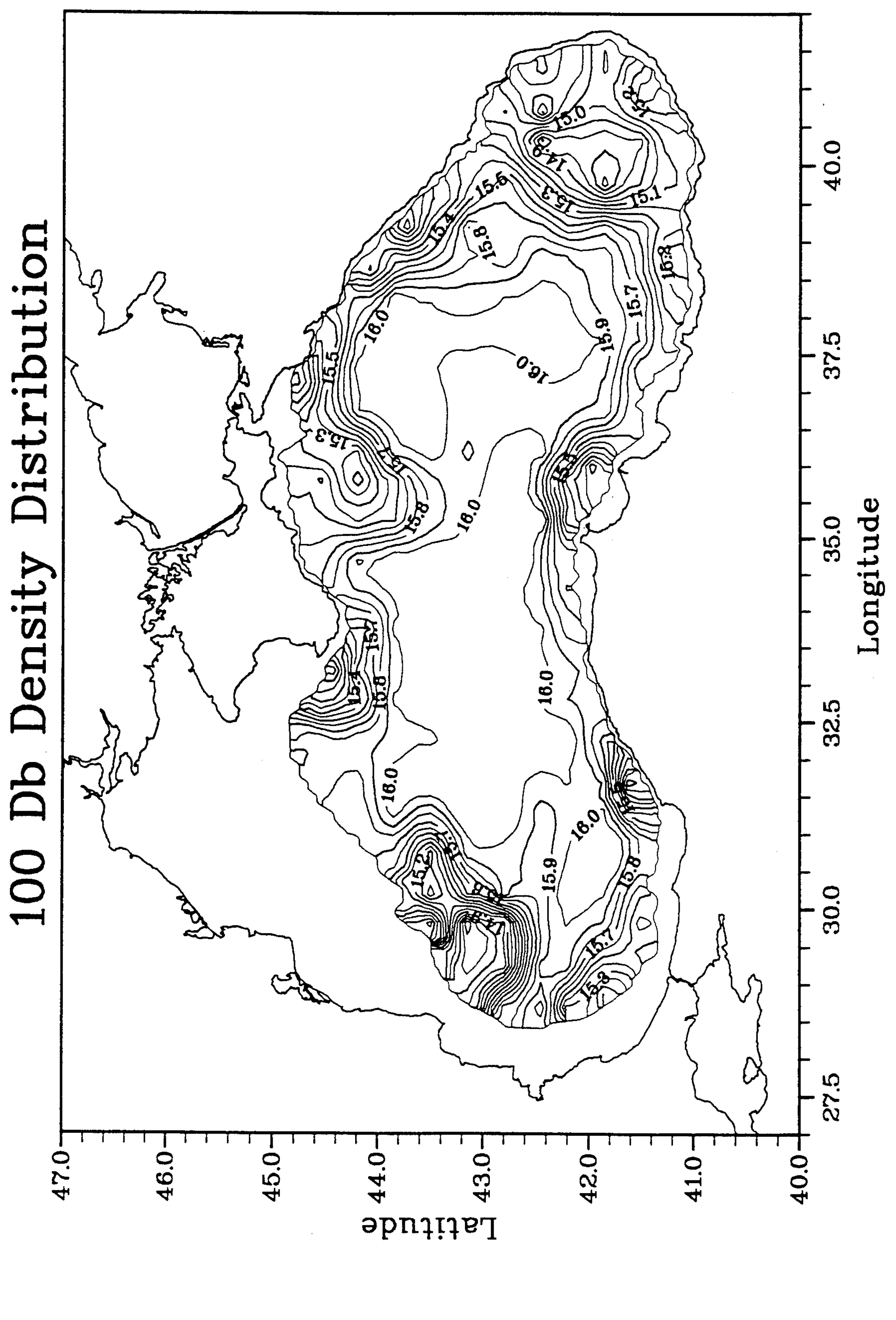
42.0
41.0
40.0


100 Db Density Distribution
Longitude
Latitude
27.5
30.0
32.5
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37.5
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44.0
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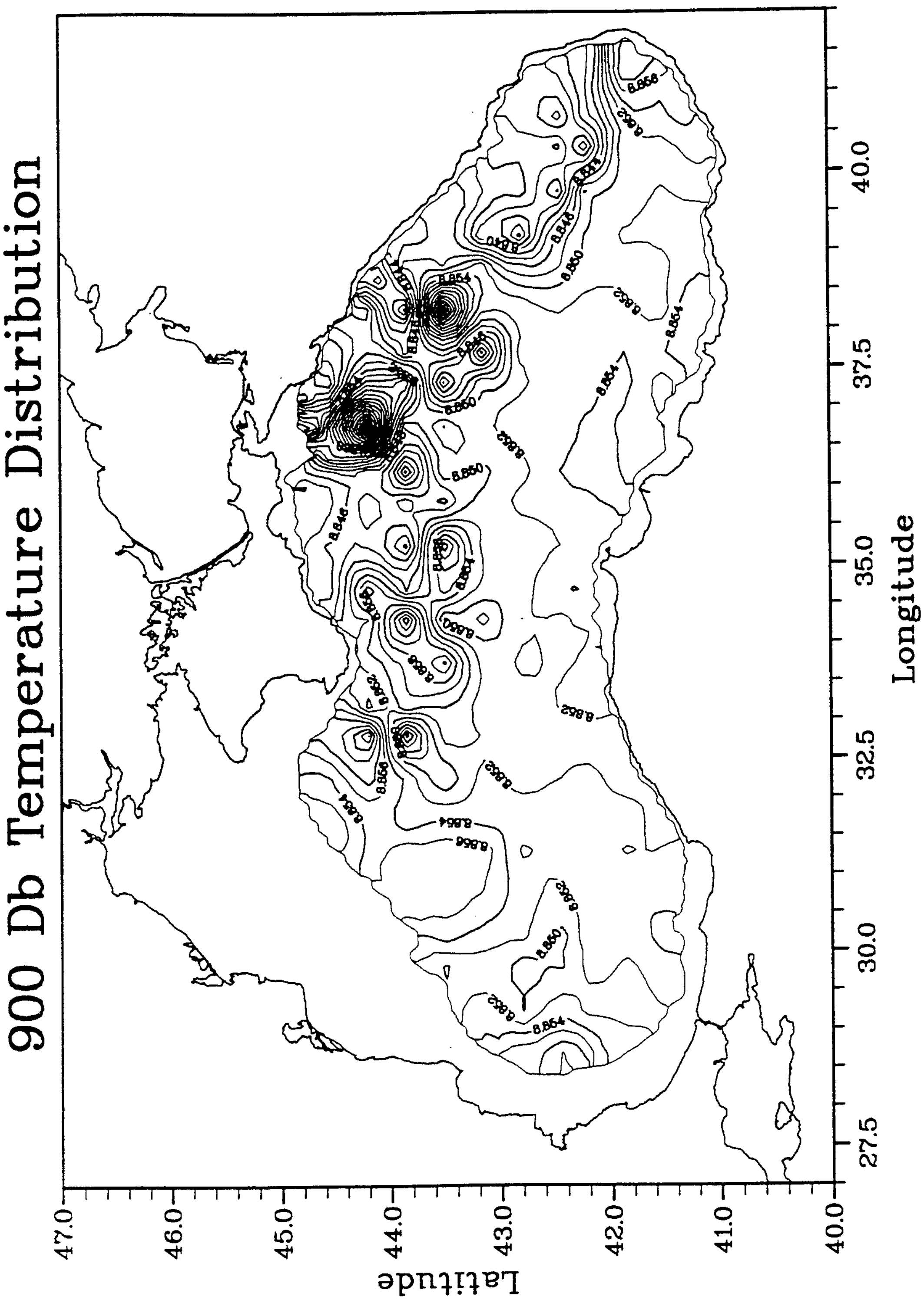
41.0
40.0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Longitude
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30.0
32.5
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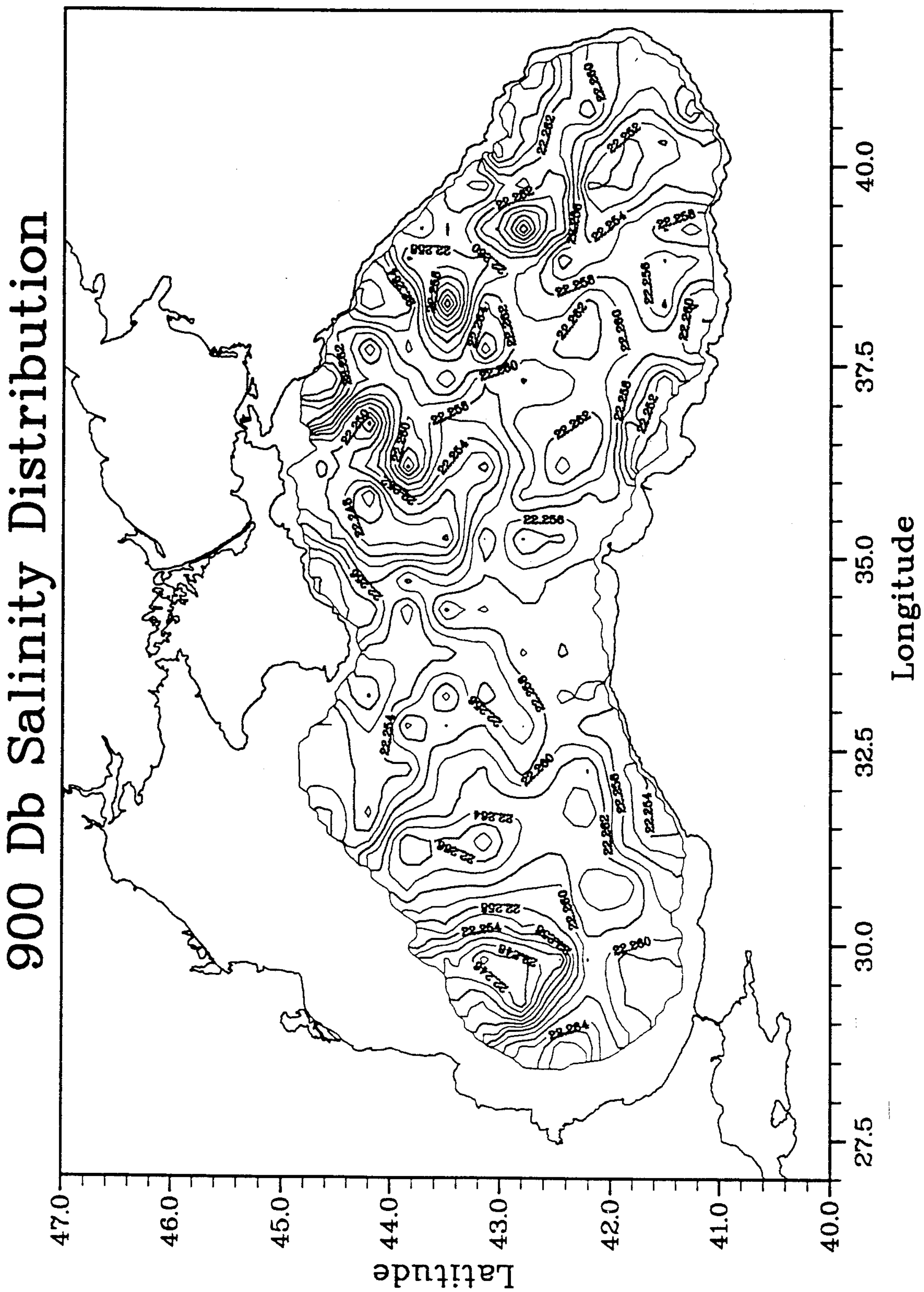
37.5
40.0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Latitude
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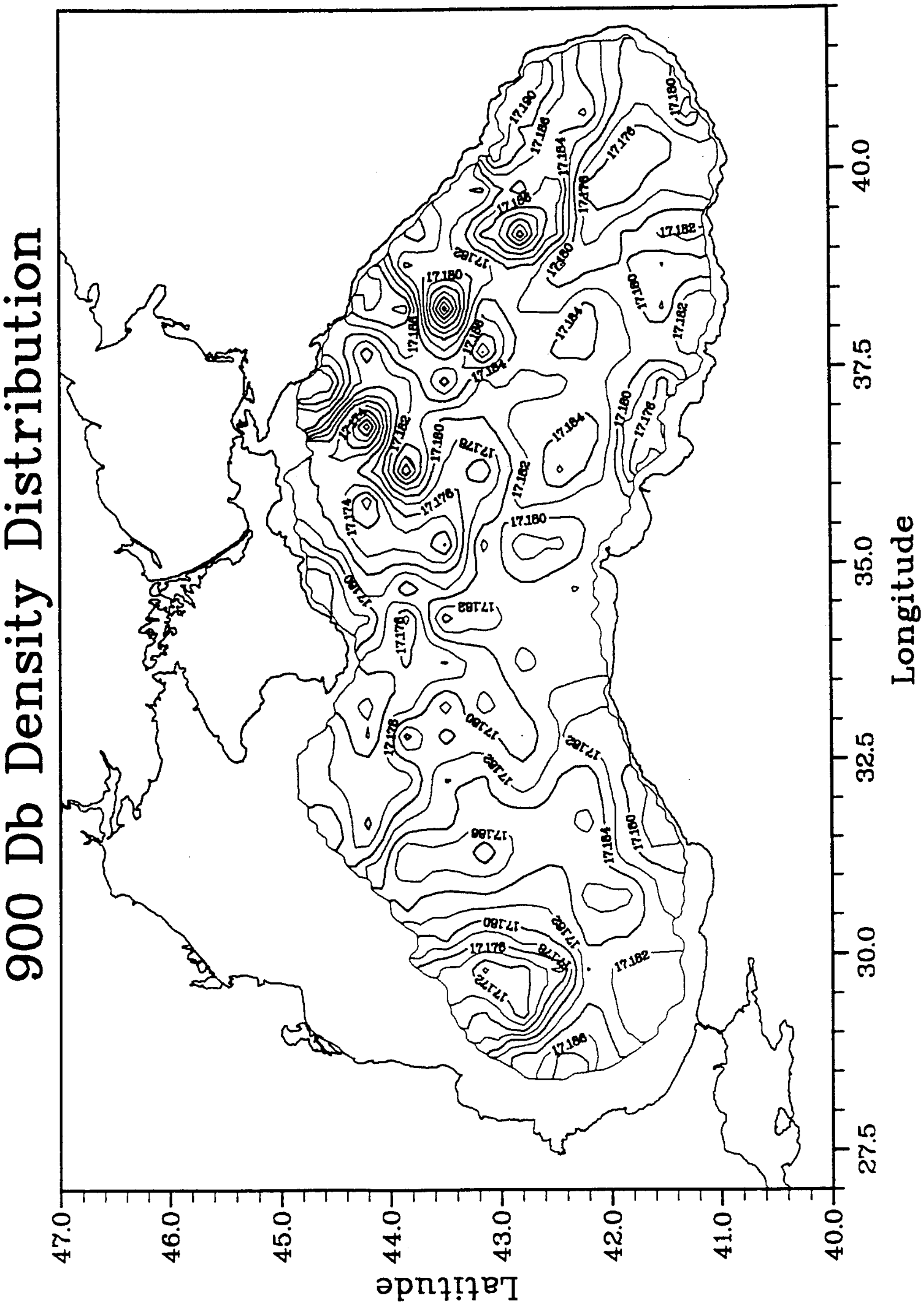
41.0
40.0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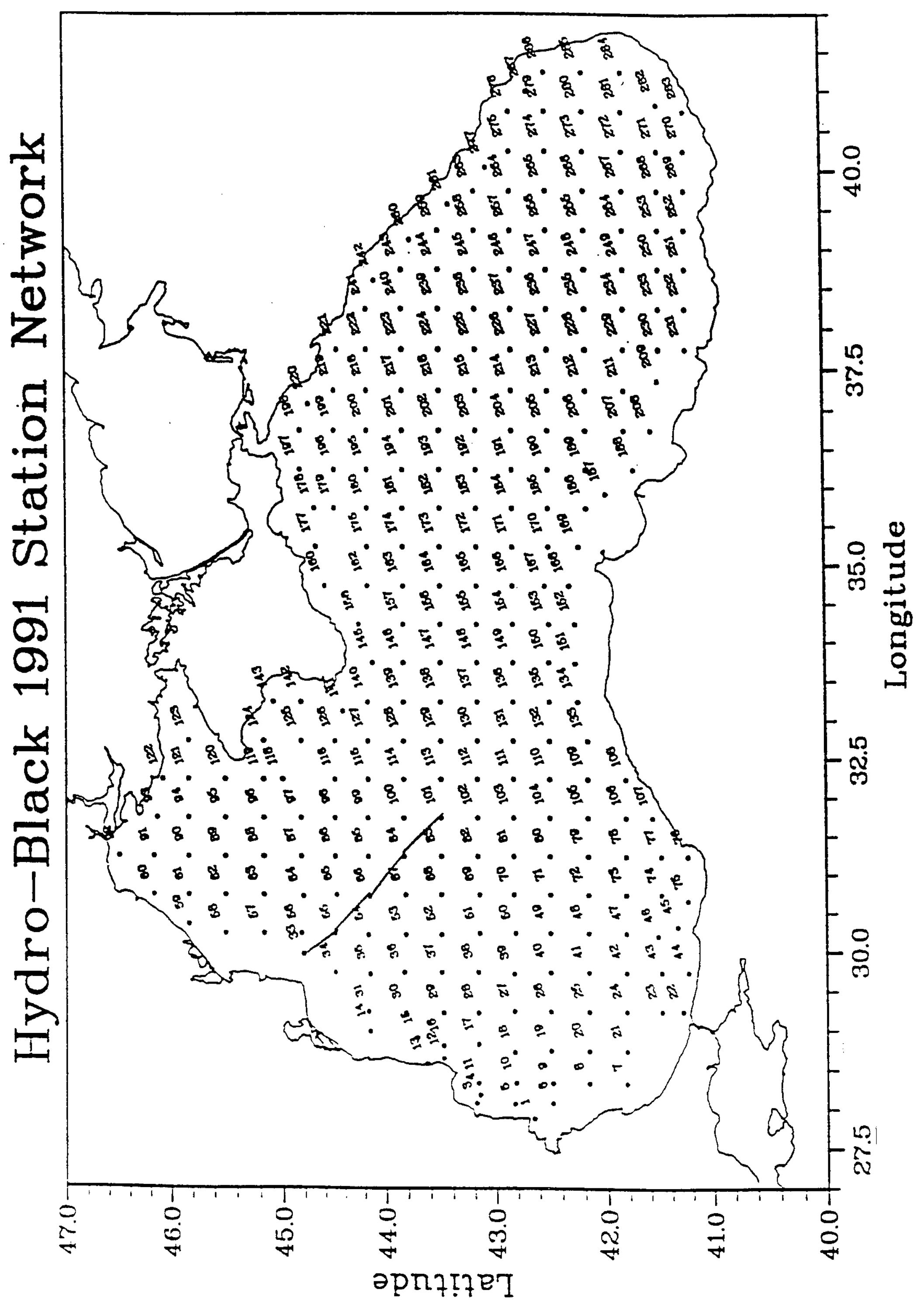
41.0
40.0


Hydro-Black 1991 Station Network
Longitude
Latitude
27.5
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32.5
35.0
37.5
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46.0
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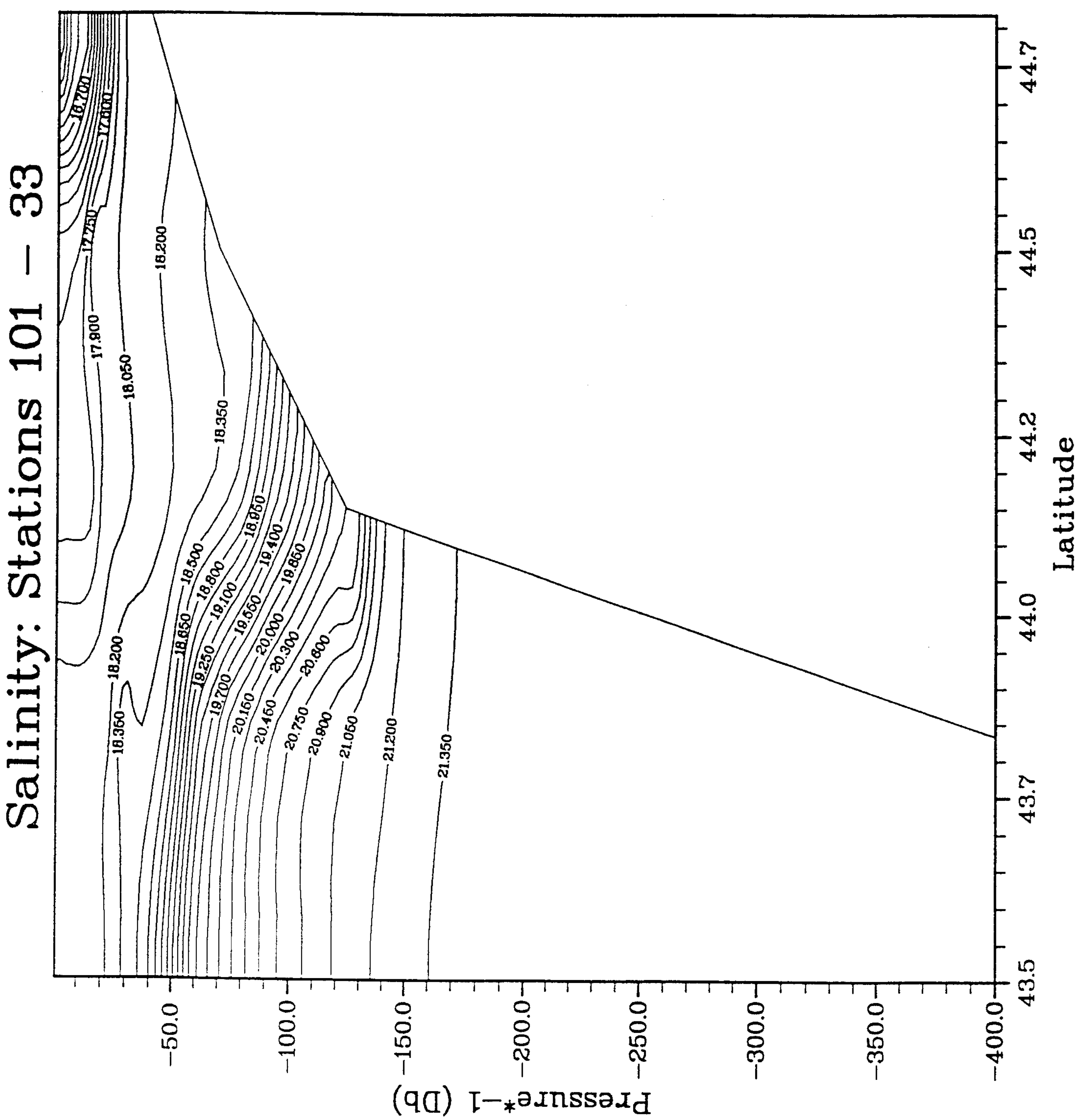
42.0
41.0
40.0


Salinity: Stations 101 – 33
Latitude
Pressure*-1 (Db)
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43.7
44.0
44.2
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-150.0
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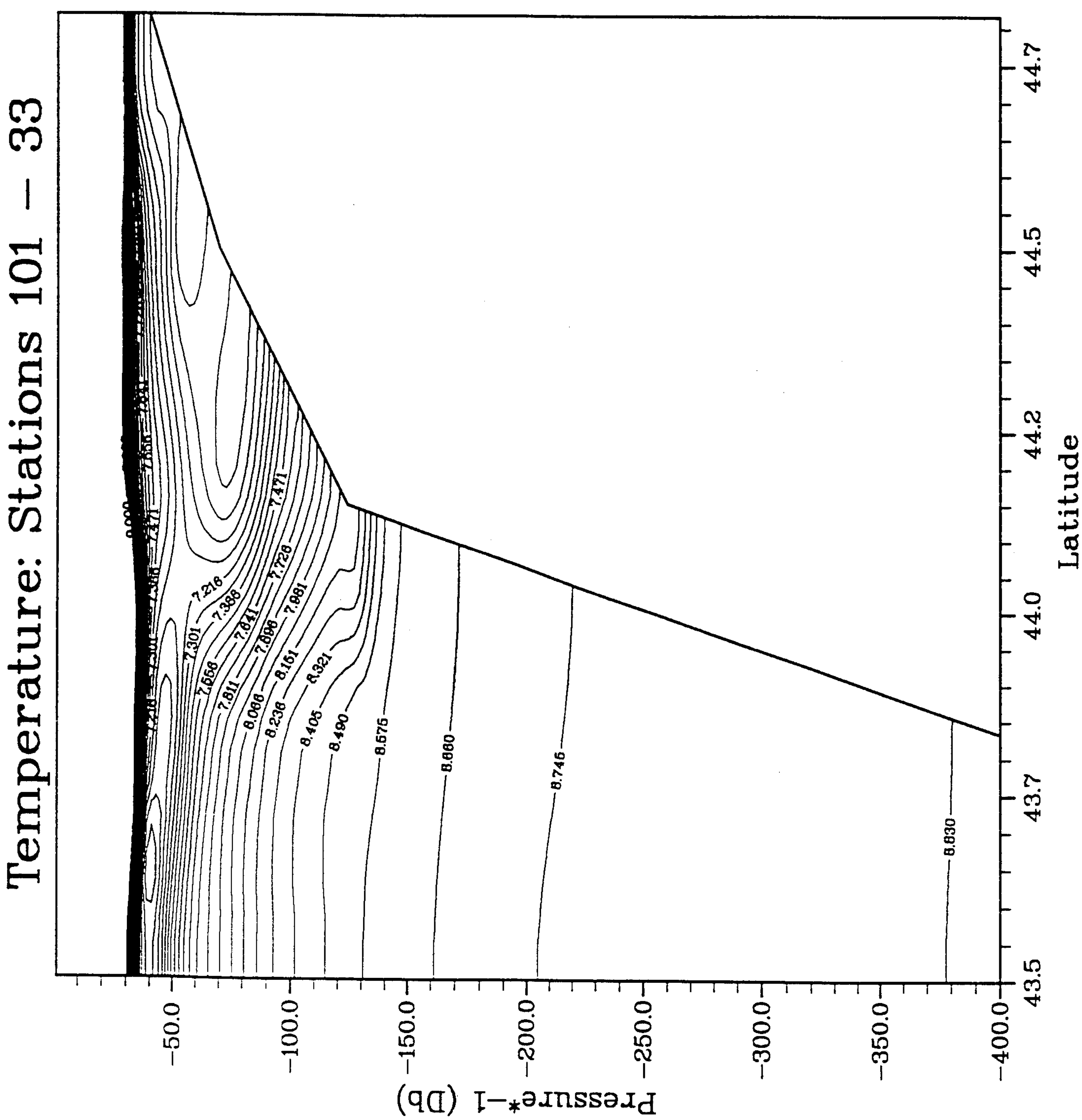
-250.0
-300.0
-350.0
-400.0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Pressure*-1 (Db)
Latitude
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-150.0
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-250.0
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43.5
43.7
44.0
44.2
44.5
44.7
7.216
7.301
7.388
7.471
7.556
7.641
7.726
7.811
7.896
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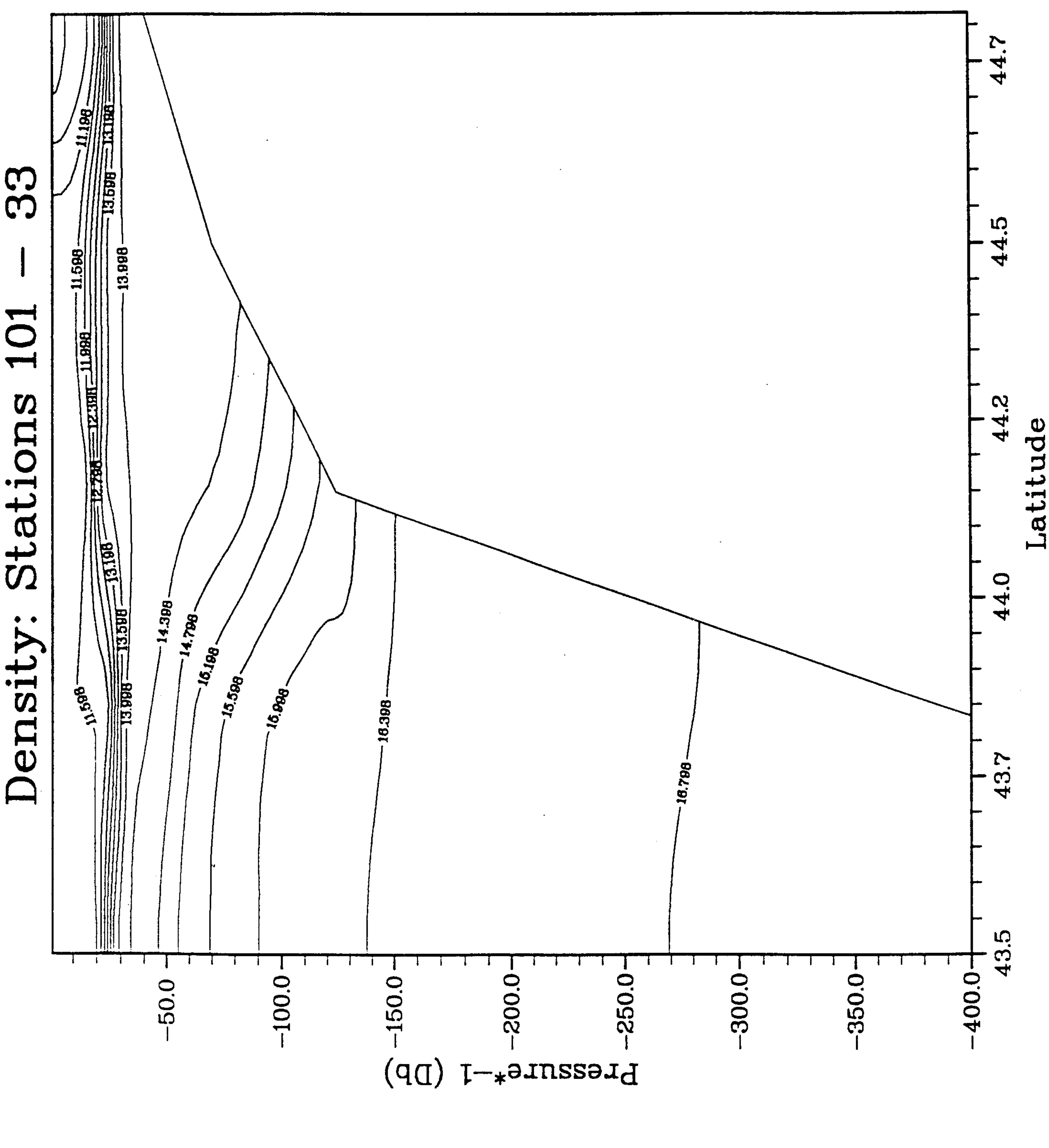
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Latitude
Pressure*-1 (Db)
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44.7
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-200.0
-250.0
-300.0
-350.0
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11.598
11.998
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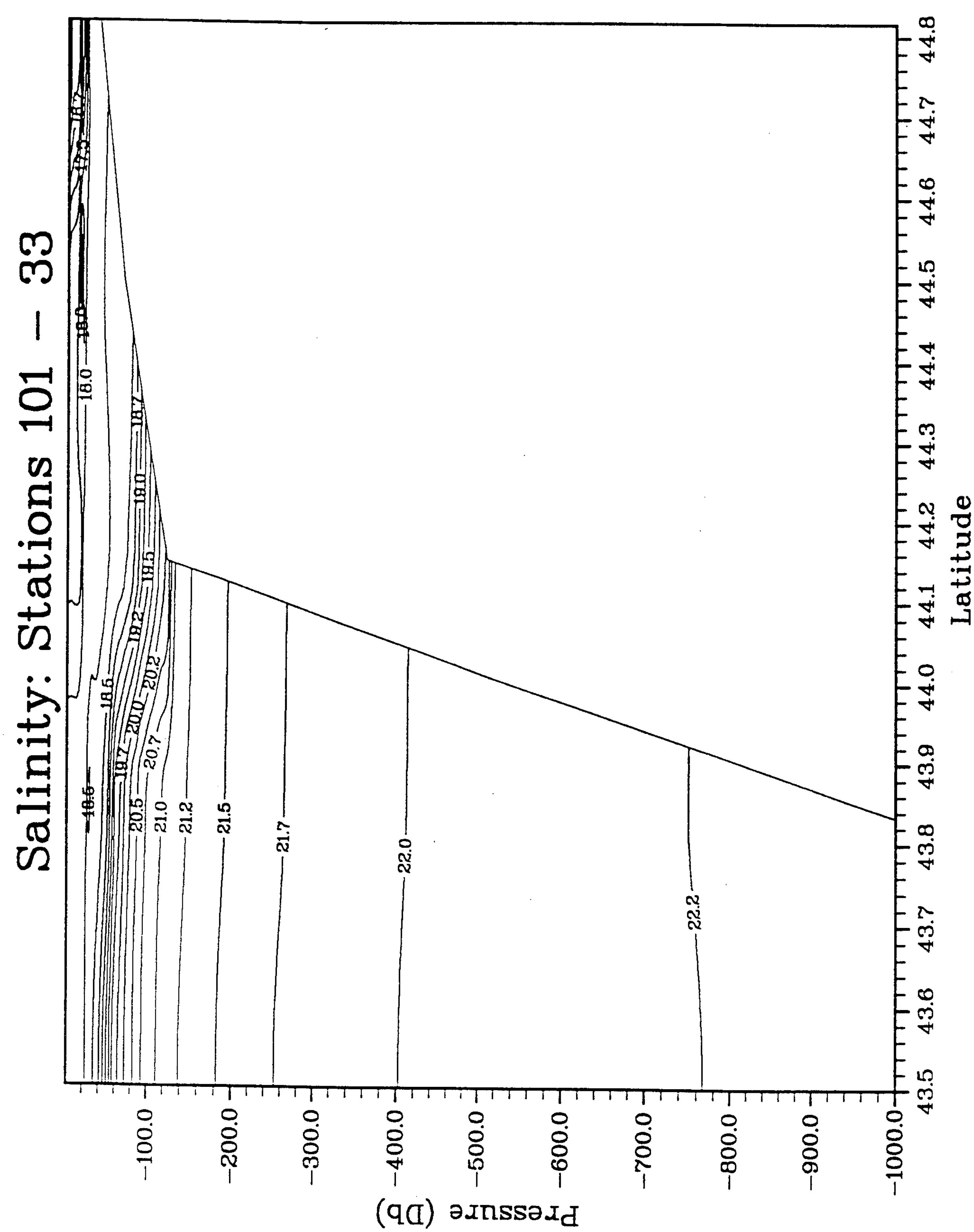
16.798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Latitude
Pressure (Db)
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43.7
43.8
43.9
44.0
44.1
44.2
44.3
44.4
44.5
44.6
44.7
44.8
-100.0
-200.0
-300.0
-400.0
-500.0
-600.0
-700.0
-800.0
-900.0
-1000.0
18.0
18.5
18.7
19.0
19.2
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21.2
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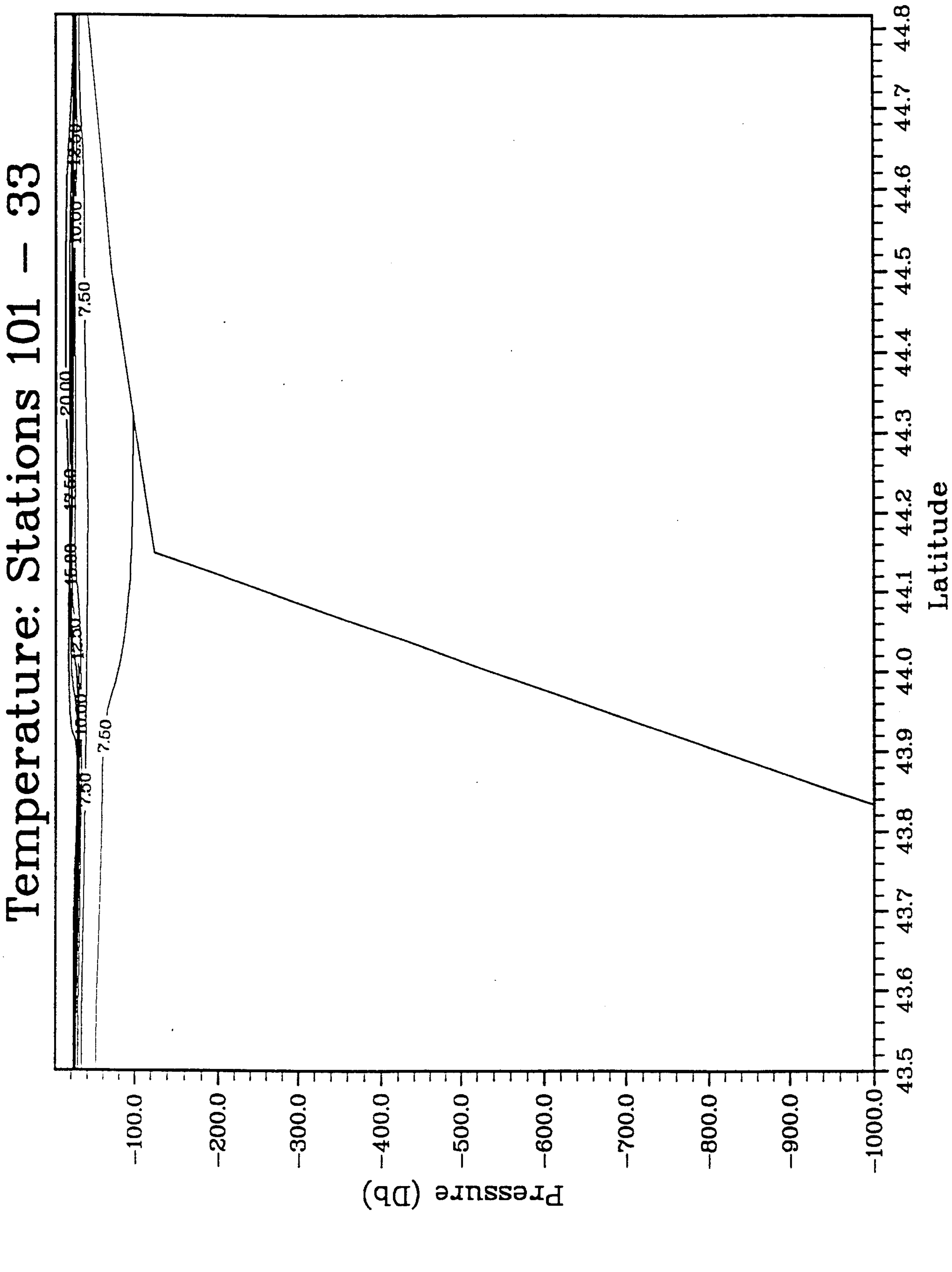
21.7
22.0
22.2


Temperature: Stations 101 — 33
Latitude
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43.7
43.8
43.9
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44.1
44.2
44.3
44.4
44.5
44.6
44.7
44.8
Pressure (Db)
-100.0
-200.0
-300.0
-400.0
-500.0
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12.50
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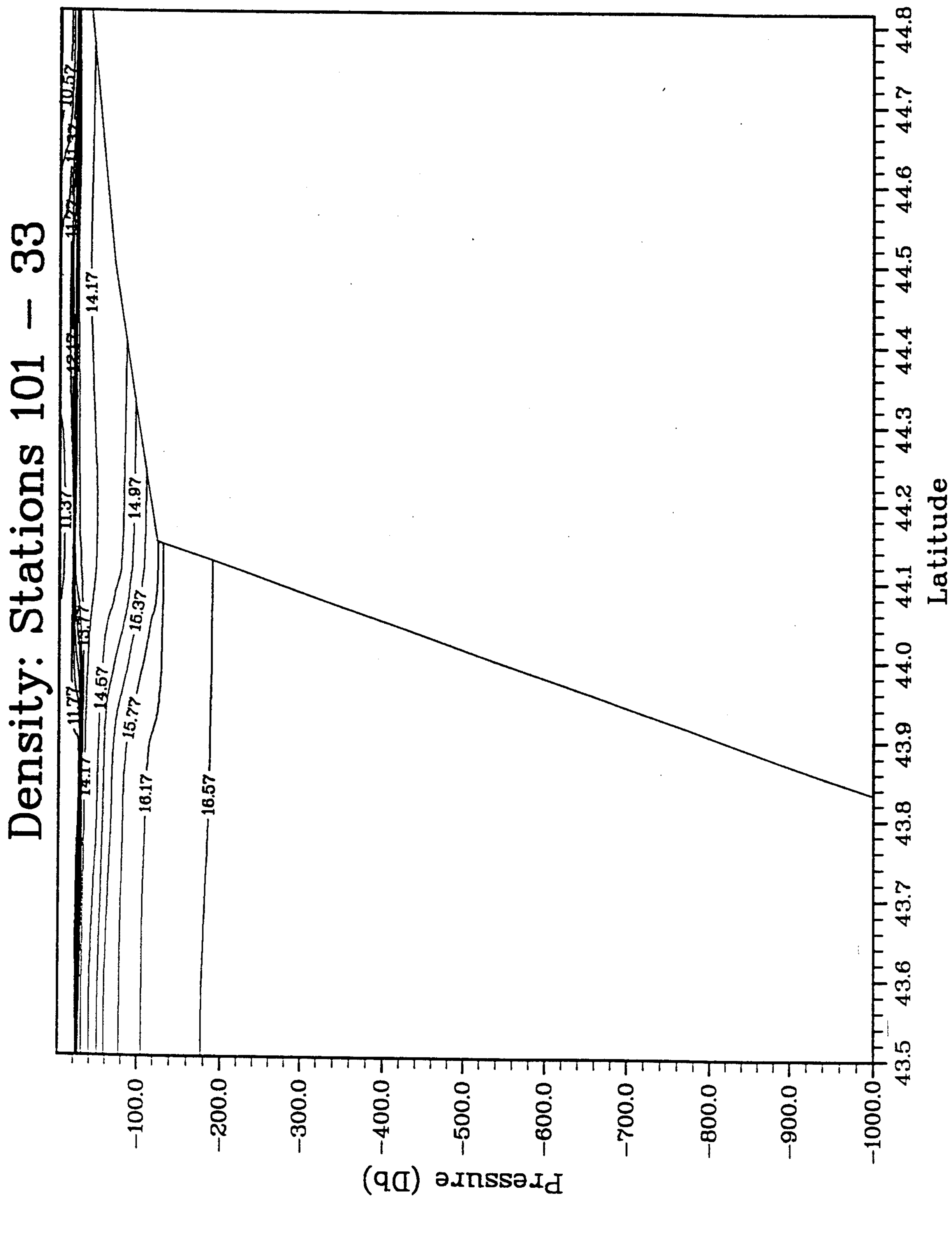
17.50
20.00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Pressure (Db)
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-800.0
-900.0
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43.5
43.6
43.7
43.8
43.9
44.0
44.1
44.2
44.3
44.4
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44.6
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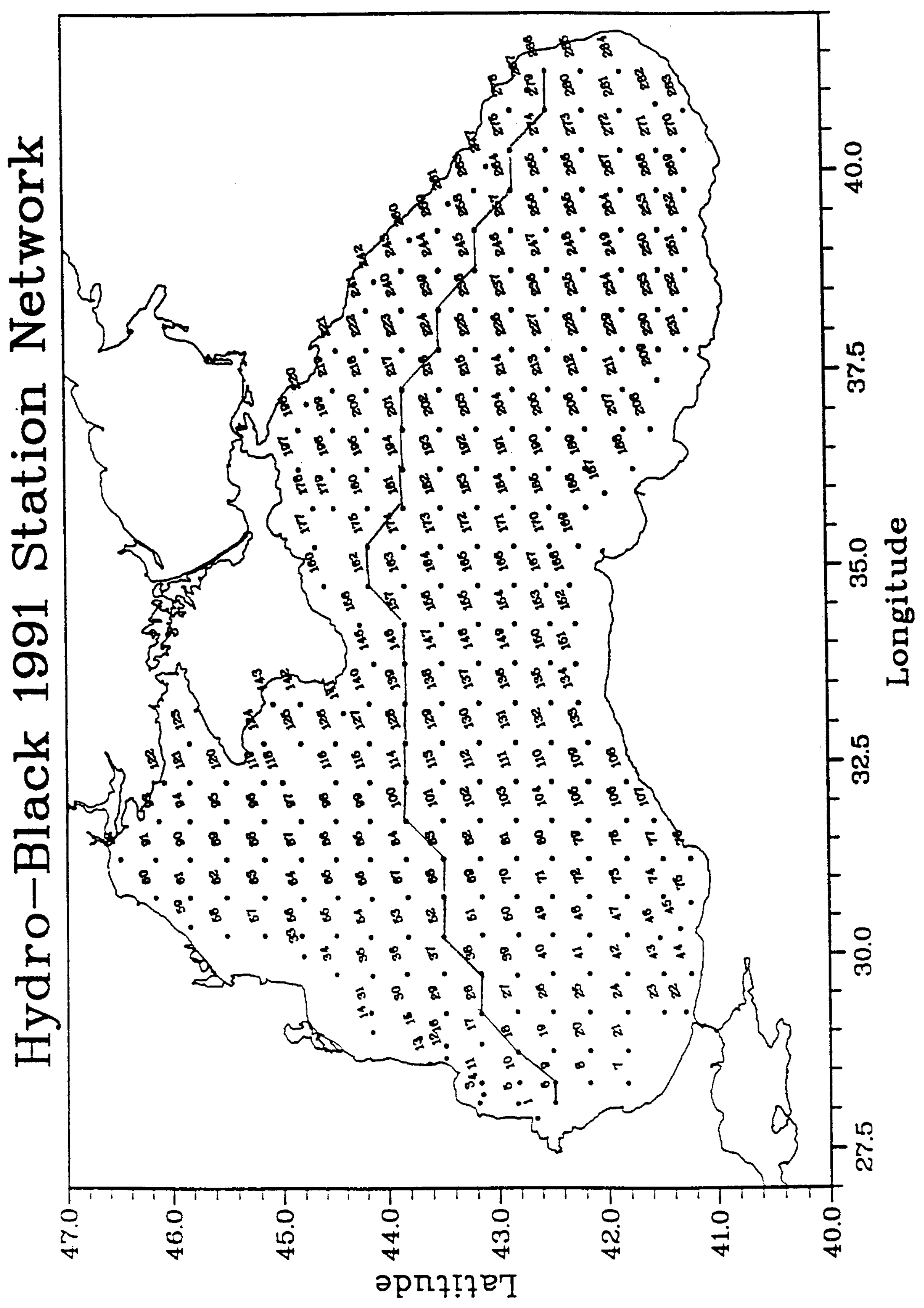
Hydro–Black 1991 Station Network
Longitude
Latitude
27.5
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37.5
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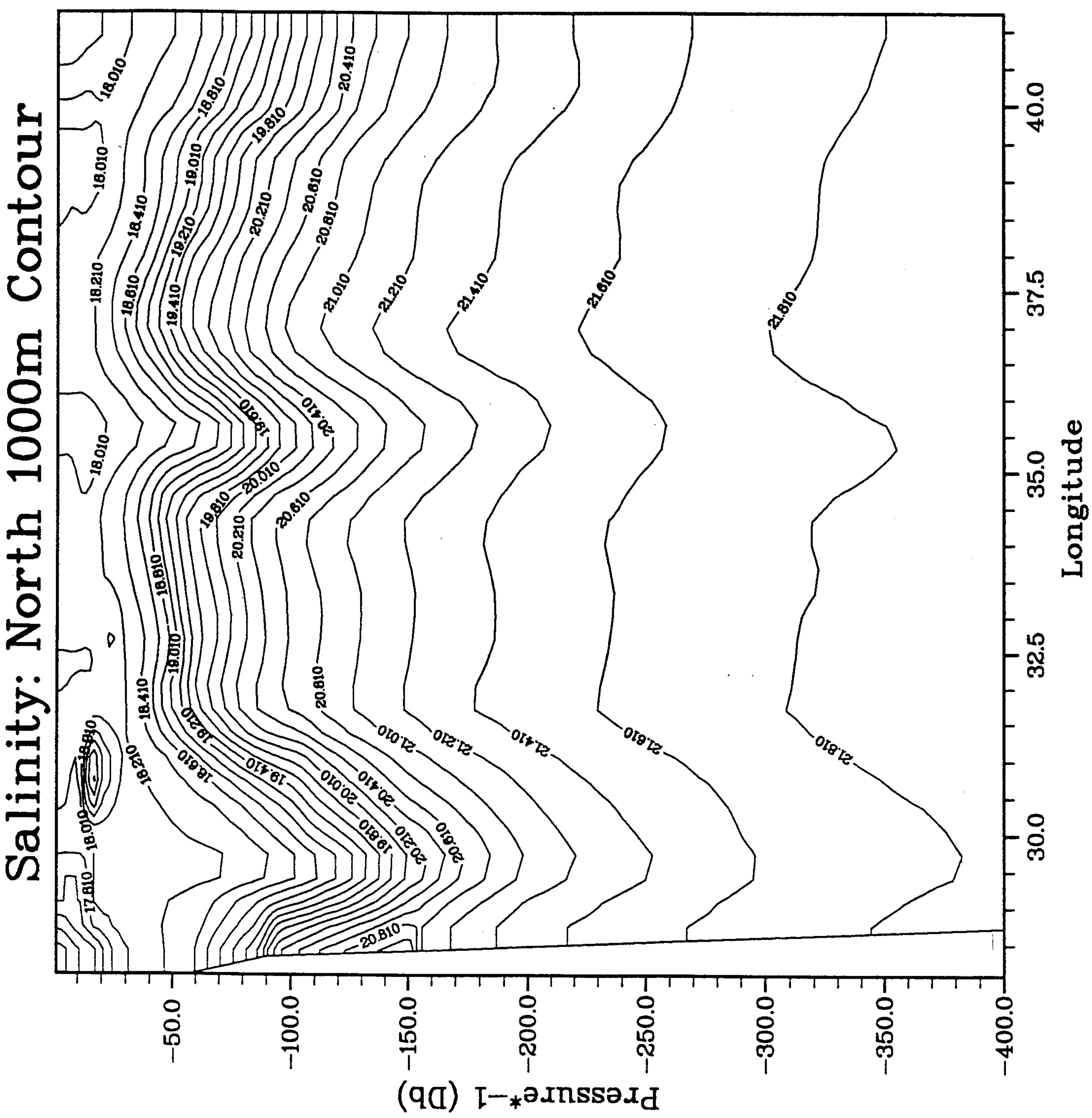
42.0
41.0
40.0


Salinity: North 1000m Contour
Longitude
Pressure*-1 (Db)
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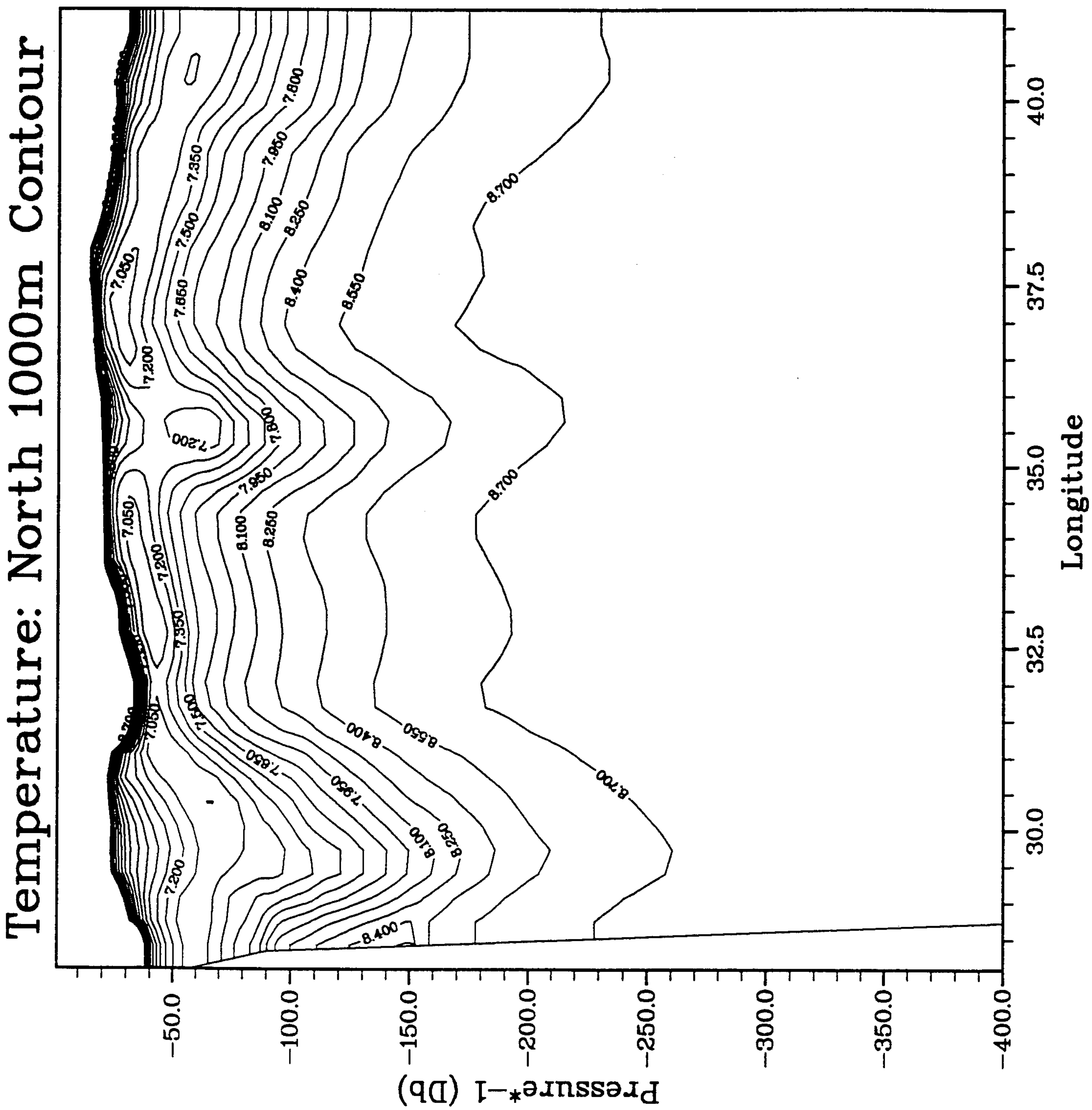
Temperature: North 1000m Contour
Longitude
30.0
32.5
35.0
37.5
40.0
Pressure*-1 (Db)
-50.0
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-150.0
-200.0
-250.0
-300.0
-350.0
-400.0
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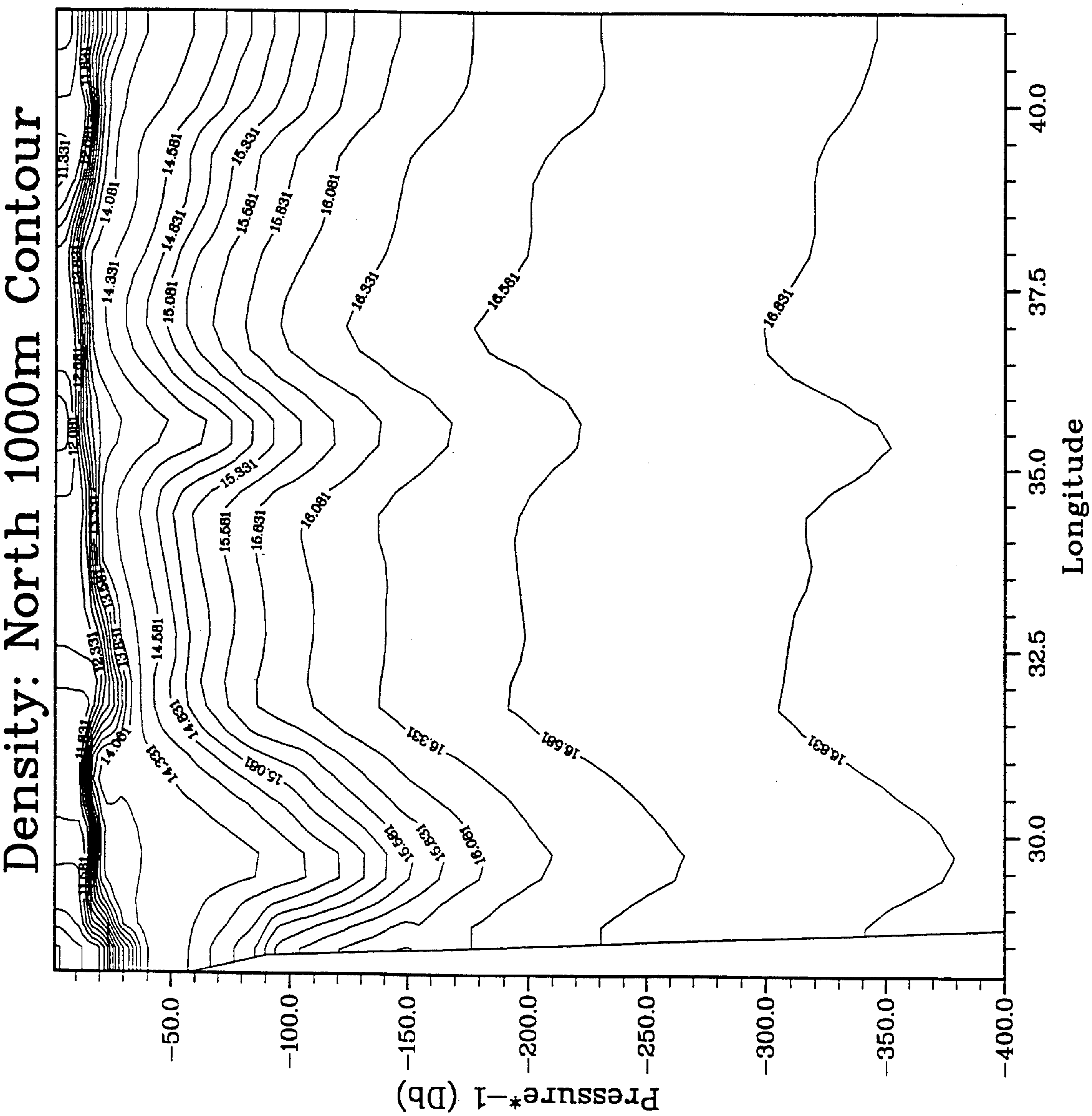
8.550
8.700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Pressure*-1 (Db)
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-200.0
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-400.0
Longitude
30.0
32.5
35.0
37.5
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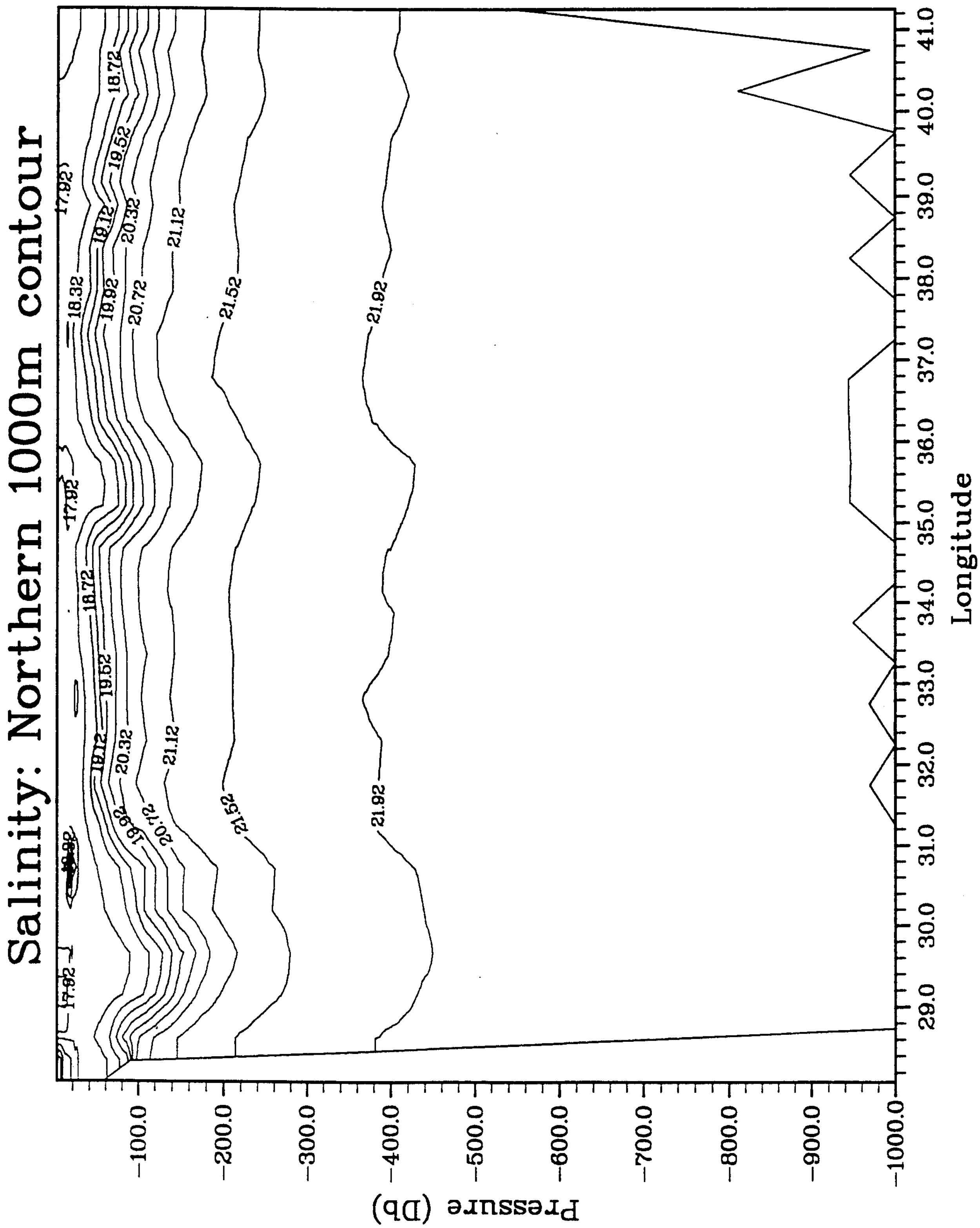
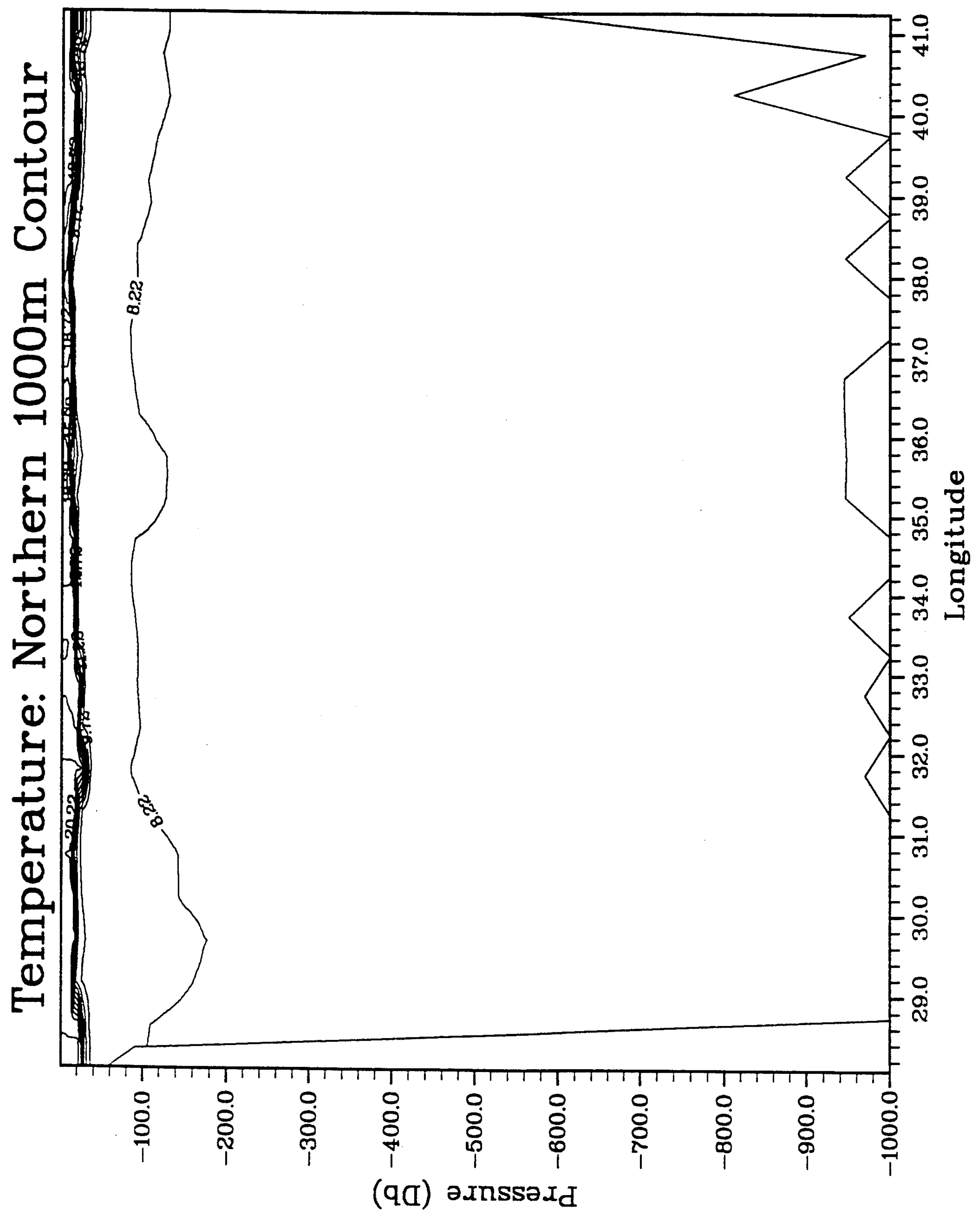
16.831


Salinity: Northern 1000m contour
Pressure (Db)
Longitude


Temperature: Northern 1000m Contour
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8.22
Pressure (Db)
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29.0
30.0
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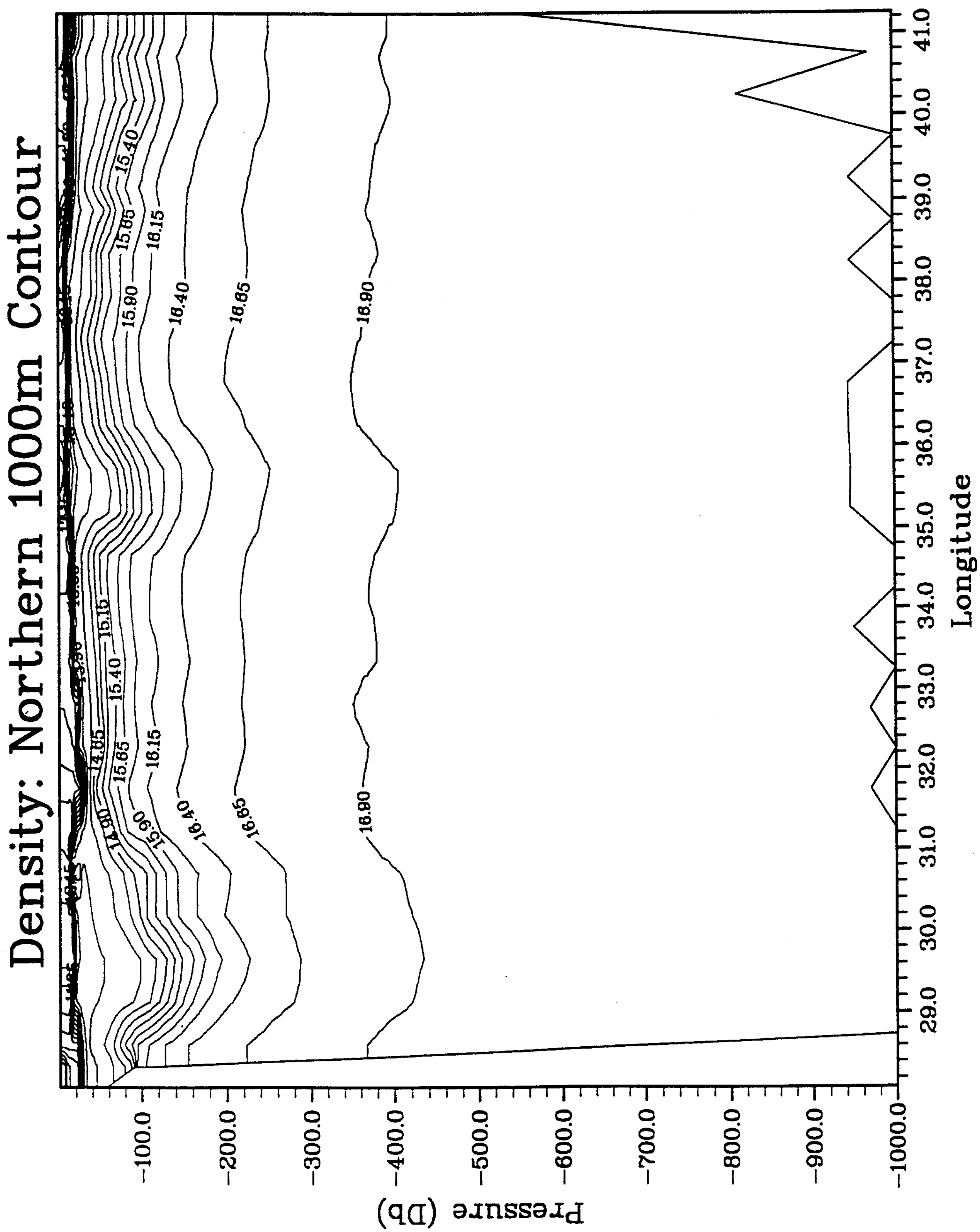
Longitude


Density: Northern 1000m Contour
Longitude
Pressure (Db)
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37.0
38.0
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-400.0
-500.0
-600.0
-700.0
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16.65
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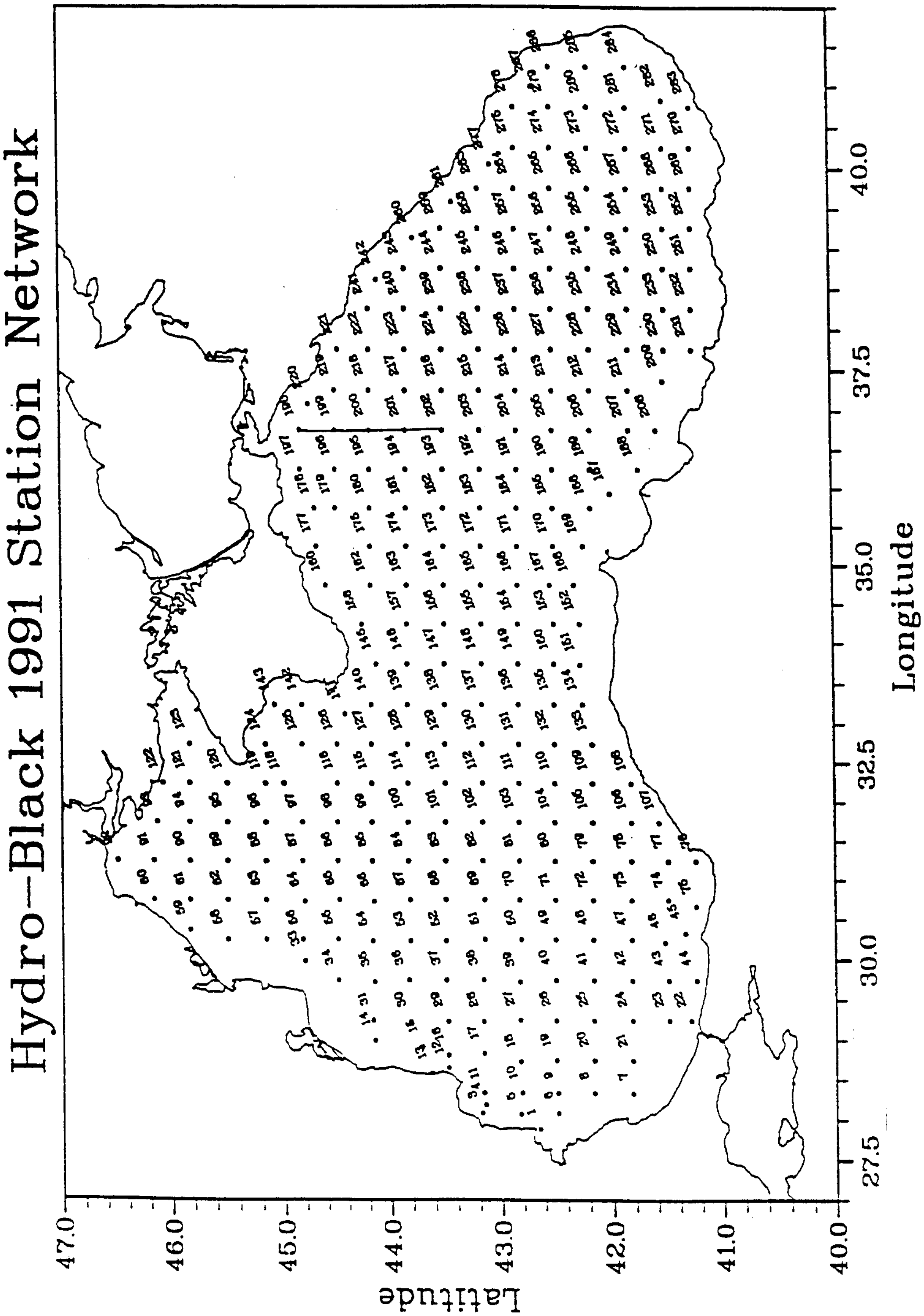
15.40


Hydro-Black 1991 Station Network
Latitude
47.0
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42.0
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40.0
Longitude
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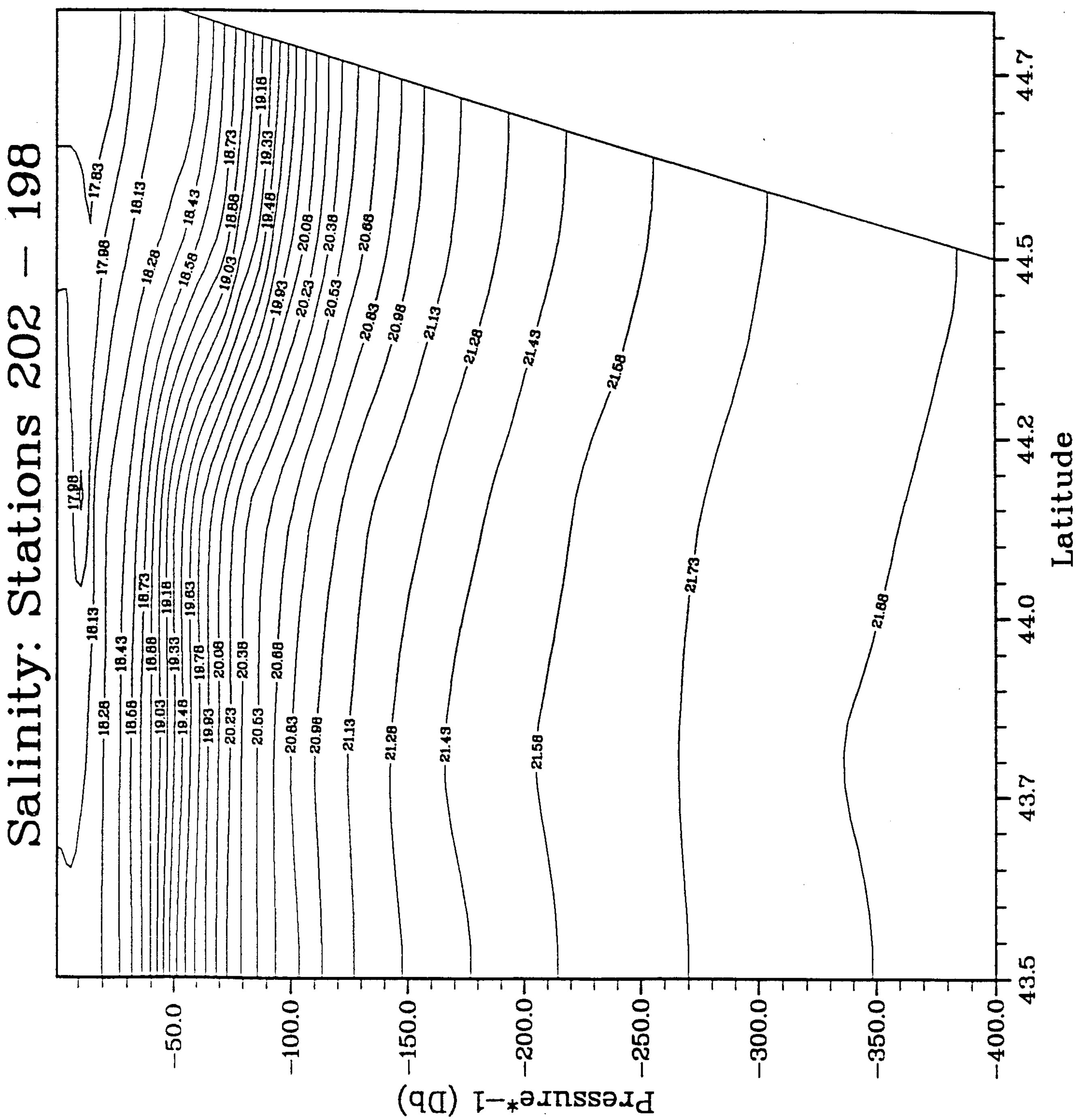
30.0
32.5
35.0
37.5
40.0


Salinity: Stations 202 – 198
Latitude
43.5
43.7
44.0
44.2
44.5
44.7
Pressure*-1 (Db)
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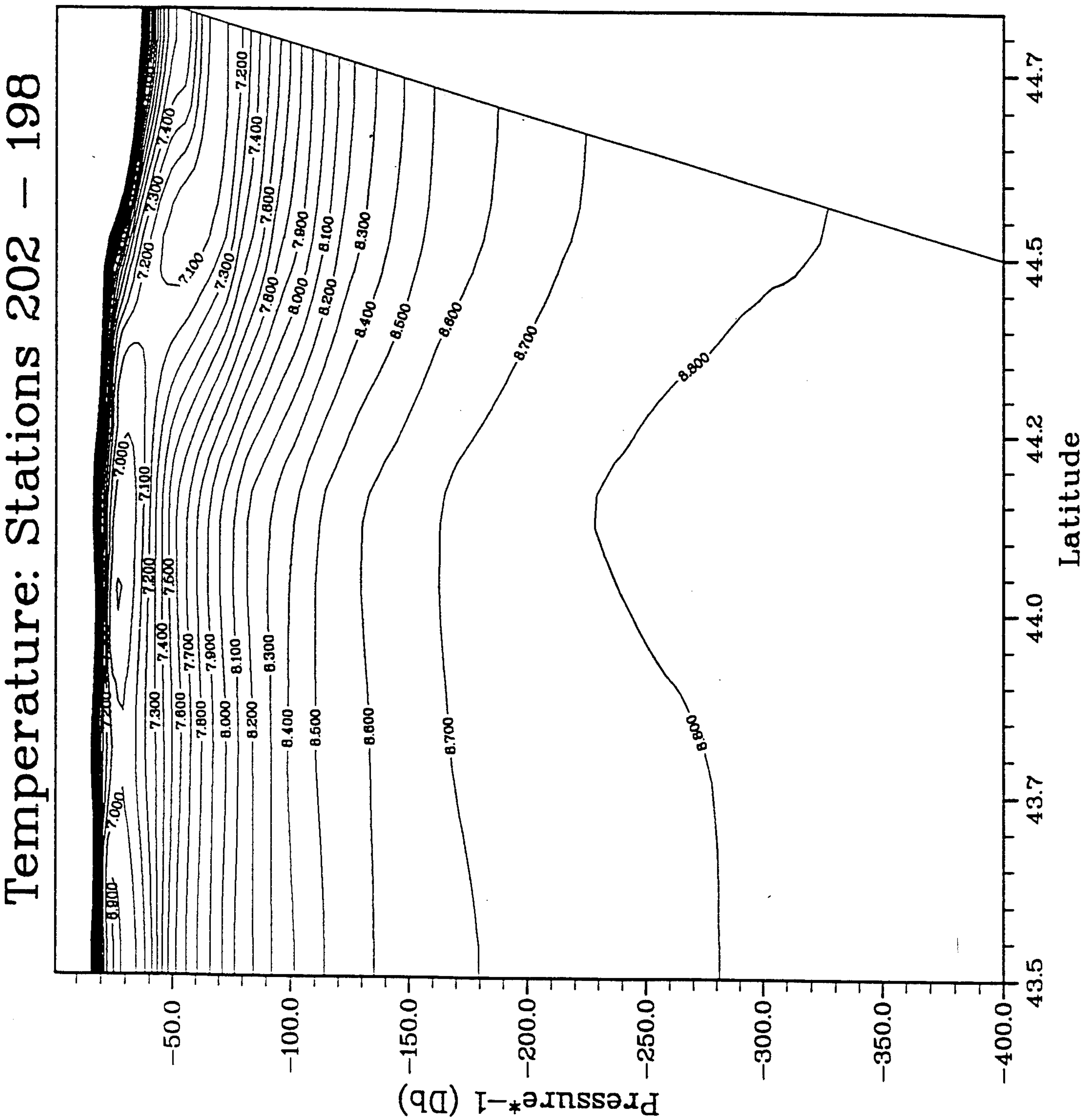
Temperature: Stations 202 – 198
Latitude
43.5
43.7
44.0
44.2
44.5
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Pressure*-1 (Db)
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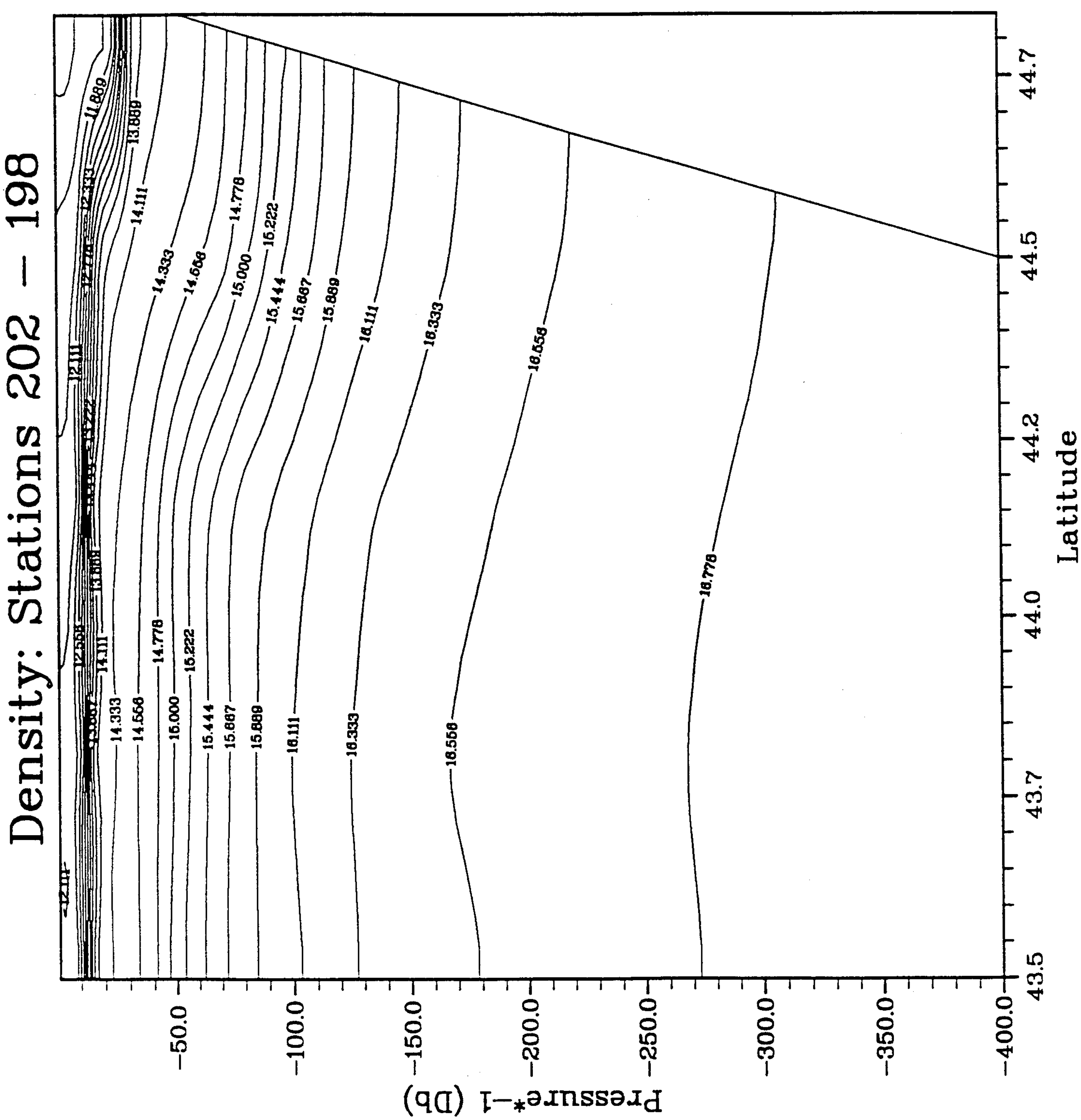
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Pressure*-1 (Db)
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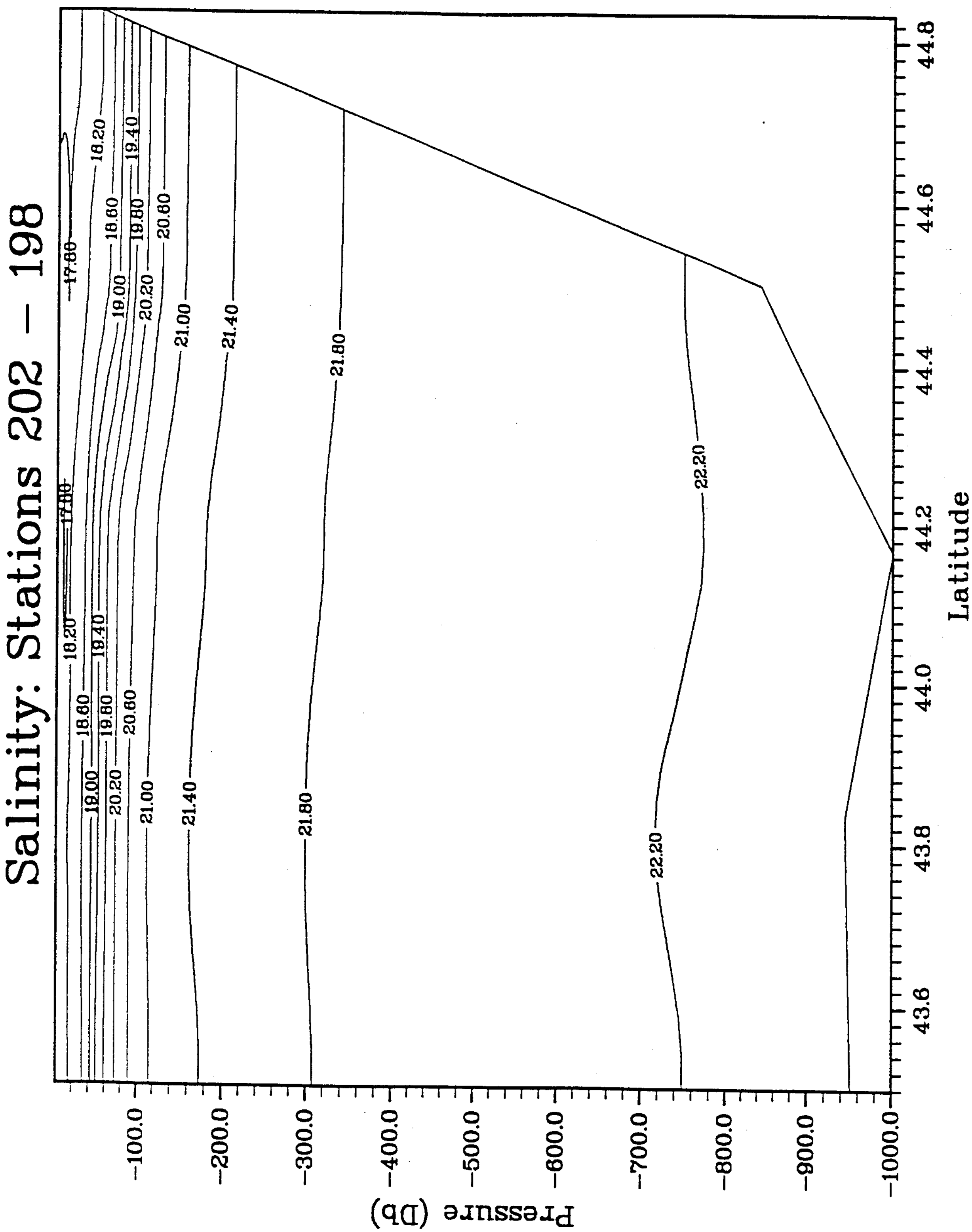
16.556
16.778


Salinity: Stations 202 – 198
Latitude
Pressure (Db)
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44.6
44.8
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-300.0
-400.0
-500.0
-600.0
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-1000.0
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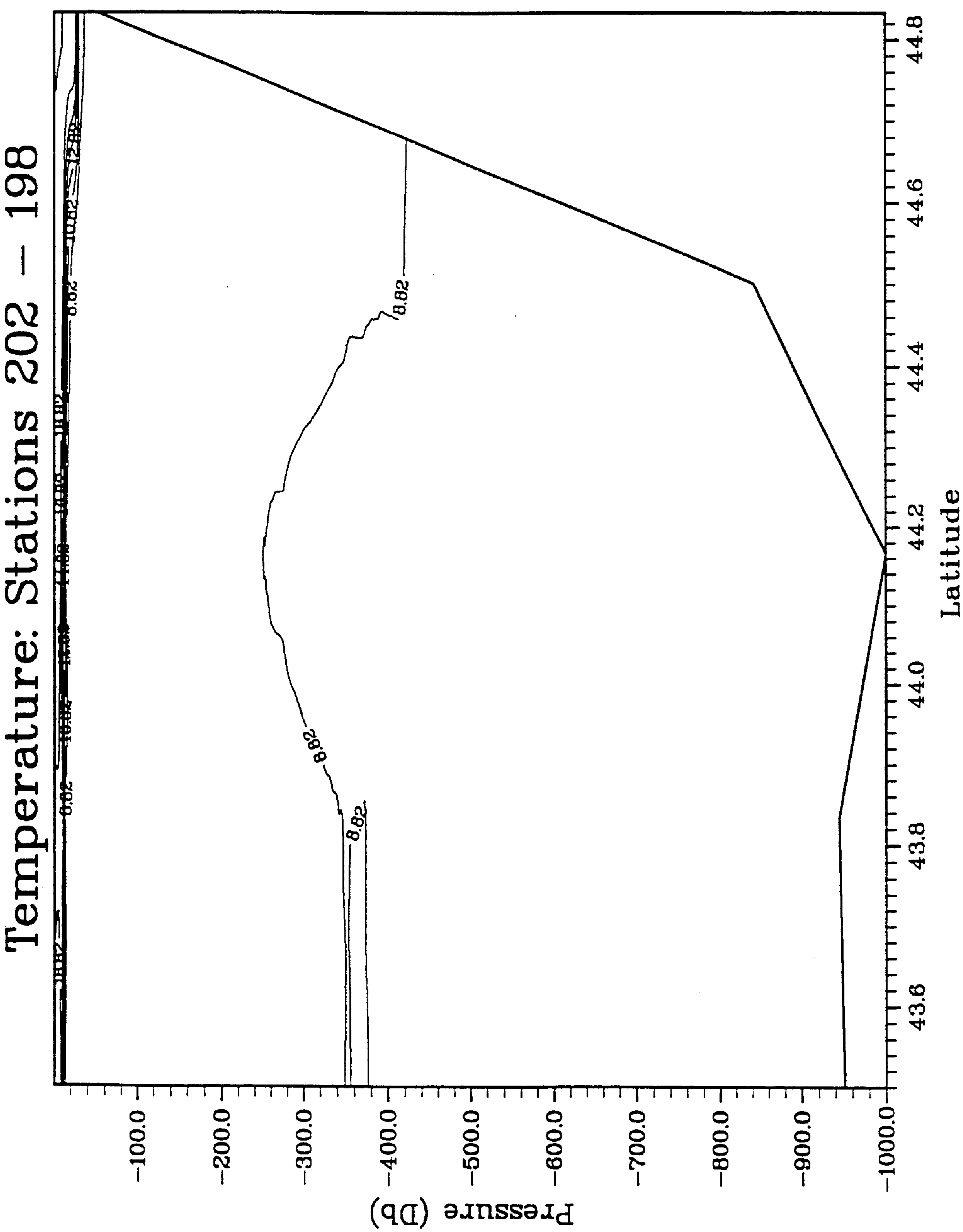
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-400.0
-500.0
-600.0
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Latitude
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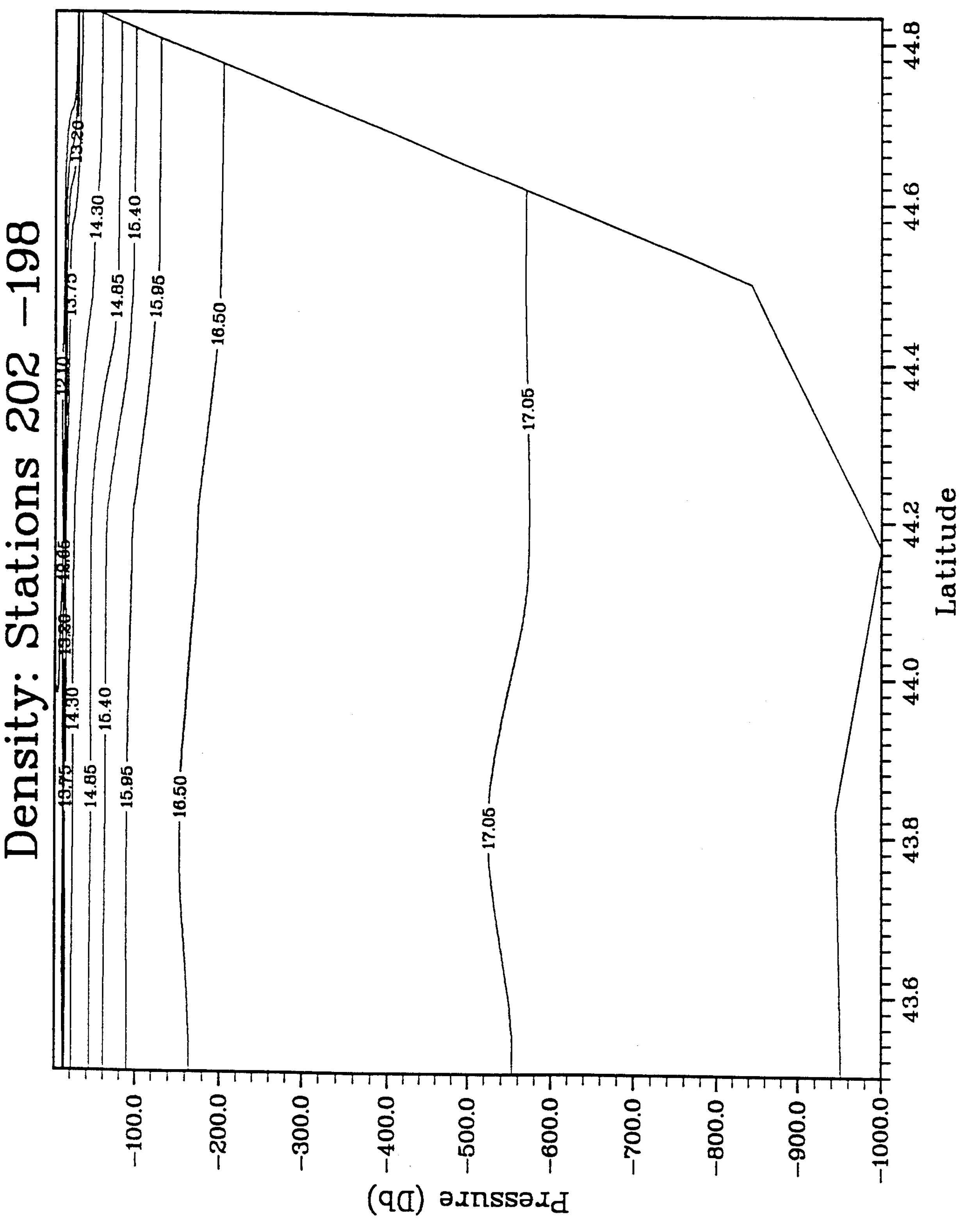
8.82
8.82


Density: Stations 202 −198
Latitude
Pressure (Db)
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43.8
44.0
44.2
44.4
44.6
44.8
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−200.0
−300.0
−400.0
−500.0
−600.0
−700.0
−800.0
−900.0
−1000.0
13.20
13.75
14.30
14.85
15.40
15.95
16.50
17.05

ANNEX VI

LIST OF PARTICIPANTS

Aubrey, David G., Woods Hole Oceanographic Institution, Woods Hole, MA., USA

Demirev, Encho, Institute of Oceanology, Bulgarian Academy of Sciences, Varna, Bulgaria

Ivanov, Vitaly, Marine Hydrophysical Institute, Sevastopol, Ukraine

McSherry, Thomas R., Woods Hole Oceanographic Institution, Woods Hole, MA., USA

Oguz, Temel, Middle East Technical University, Erdemli, Turkey

No.	Title	Languages
52	SCOR-IOC-UNESCO Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects upon Living Resources and the Atmosphere; Paris, 6-10 May 1985.	E
53	IOC Workshop on the Biological Effects of Pollutants; Oslo, 11-29 August 1986.	E
54	Workshop on Sea-Level Measurements in Hostile Conditions; Bidston, UK, 28-31 March 1988	E
55	IBCCA Workshop on Data Sources and Compilation, Boulder, Colorado, 18-19 July 1988.	E
56	IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Cleveland, Australia, 24-30 July 1988.	E
57	IOC Workshop on International Co-operation in the Study of Red Tides and Ocean Blooms; Takamatsu, Japan, 16-17 November 1987.	E
58	International Workshop on the Technical Aspects of the Tsunami Warning System; Novosibirsk, USSR, 4-5 August 1989.	E
58 Suppl.	Second International Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation. *Submitted Papers*; Novosibirsk, USSR, 4-5 August 1989.	E
59	IOC-UNEP Regional Workshop to Review Priorities for Marine Pollution Monitoring Research, Control and Abatement in the Wider Caribbean; San José, Costa Rica, 24-30 August 1989.	E, F, S
60	IOC Workshop to Define IOCARIBE-TRODERP proposals; Caracas, Venezuela, 12-16 September 1989.	E
61	Second IOC Workshop on the Biological Effects of Pollutants; Bermuda, 10 September-2 October 1988.	E
62	Second Workshop of Participants in the Joint FAO-IOC-WHO-IAEA-UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region; Accra, Ghana, 13-17 June 1988.	E
63	IOC/WESTPAC Workshop on Co-operative Study of the Continental Shelf Circulation in the Western Pacific; Bangkok, Thailand, 31 October-3 November 1989.	E
64	Second IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Phuket, Thailand, 25-31 September 1989.	E
65	Second IOC Workshop on Sardine/Anchovy Recruitment Project (SARP) int he Southwest Atlantic; Montevideo, Uruguay, 21-23 August 1989.	E
66	IOC *ad hoc* Expert Consultation on Sardine/Anchovy Recruitment Programme; La Jolla, California, USA, 1989.	E
67	Interdisciplinary Seminar on Research Problems in the IOCARIBE Region; Caracas, Venezuela, 28 November-1 December 1989.	E (out of stock)
68	International Workshop on Marine Acoustics; Beijing, China, 26-30 March 1990.	E
69	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Leningrad, USSR, 28-31 May 1990.	E
69 Suppl.	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Leningrad, USSR, 28-31 May 1990.	E
70	IOC-SAREC-UNEP-FAO-IAEA-WHO Workshop on Regional Aspects of Marine Pollution; Mauritius, 29 October - 9 November 1990.	E
71	IOC-FAO Workshop on the Identification of Penaeid Prawn Larvae and Postlarvae; Cleveland, Australia, 23-28 September 1990.	E
72	IOC/WESTPAC Scientific Steering Group Meeting on Co-Operative Study of the Continental Shelf Circulation in the Western Pacific; Kuala Lumpur; Malaysia, 9-11 October 1990.	E
73	Expert Consultation for the IOC Programme on Coastal Ocean Advanced Science and Technology Study; Liège, Belgium, 11-13 May 1991.	E
74	IOC-UNEP Review Meeting on Oceanographic Processes of Transport and Distribution of Pollutants in the Sea; Zagreb, Yugoslavia, 15-18 May 1989.	E
75	IOC-SCOR Workshop on Global Ocean Ecosystem Dynamics; Solomons, Maryland, USA, 29 April-2 May 1991.	E
76	IOC/WESTPAC Scientific Symposium on Marine Science and Management of Marine Areas of the Western Pacific; Penang, Malaysia, 2-6 December 1991.	E
77	IOC-SAREC-KMFRI Regional Workshop on Causes and Consequences of Sea-Level Changes on the Western Indian Ocean Coasts and Islands; Mombasa, Kenya, 24-28 June 1991.	E
78	IOC-CEC-ICES-WMO-ICSU Ocean Climate Data Workshop Goddard Space Flight Center; Greenbelt, Maryland, USA, 18-21 February 1992.	E
79	IOC/WESTPAC Workshop on River Inputs of Nutrients to the Marine Environment in the WESTPAC Region; Penang, Malaysia, 26-29 November 1991.	E
80	IOC-SCOR Workshop on Programme Development for Harmful Algae Blooms; Newport, USA, 2-3 November 1991.	E
81	Joint IAPSO-IOC Workshop on Sea Level Measurements and Quality Control; Paris, 12-13 October 1992.	E
82	BORDOMER 92: International Convention on Rational Use of Coastal Zones. A Preparatory Meeting for the Organization of an International Conference on Coastal Change; Bordeaux, France, 30 September-2 October 1992.	E
83	IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 12-13 October 1992.	E
84	Workshop on Atlantic Ocean Climate Variability; Moscow, Russian Federation, 13-17 July 1992.	E
85	IOC Workshop on Coastal Oceanography in Relation to Integrated Coastal Zone Management; Kona, Hawaii, 1-5 June 1992.	E
86	International Workshop on the Black Sea; Varna, Bulgaria 30 September - 4 October 1991.	E
87	Taller de trabajo sobre efectos biológicos del fenómeno «El Niño» en ecosistemas costeros del Pacífico Sudeste; Santa Cruz, Galápagos, Ecuador, 5-14 de octubre de 1989.	S only (Summary in E, F, S)
88	IOC-CEC-ICSU-ICES Regional Workshop for Member States of Eastern and Northern Europe (GODAR Project); Obninsk, Russia, 17-20 May 1993.	E
89	IOC-ICSEM Workshop on Ocean Sciences in Non-Living Resources; Perpignan, France, 15-20 October 1990.	E
90	IOC Seminar on Integrated Coastal Management; New Orleans, USA. 17-18 July 1993.	E
91	Hydroblack '91 CTD Intercalibration Workshop; Woods Hole, USA. 1-10 December 1991.	E